STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

CALIFORNIA JOURNAL OF MINES AND GEOLOGY

Volume 54, Number 1
JANUARY 1958

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DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

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GOODWIN J. KNIGHT, Governor
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DIVISION OF MINES
OLAF P. JENKINS, Chief

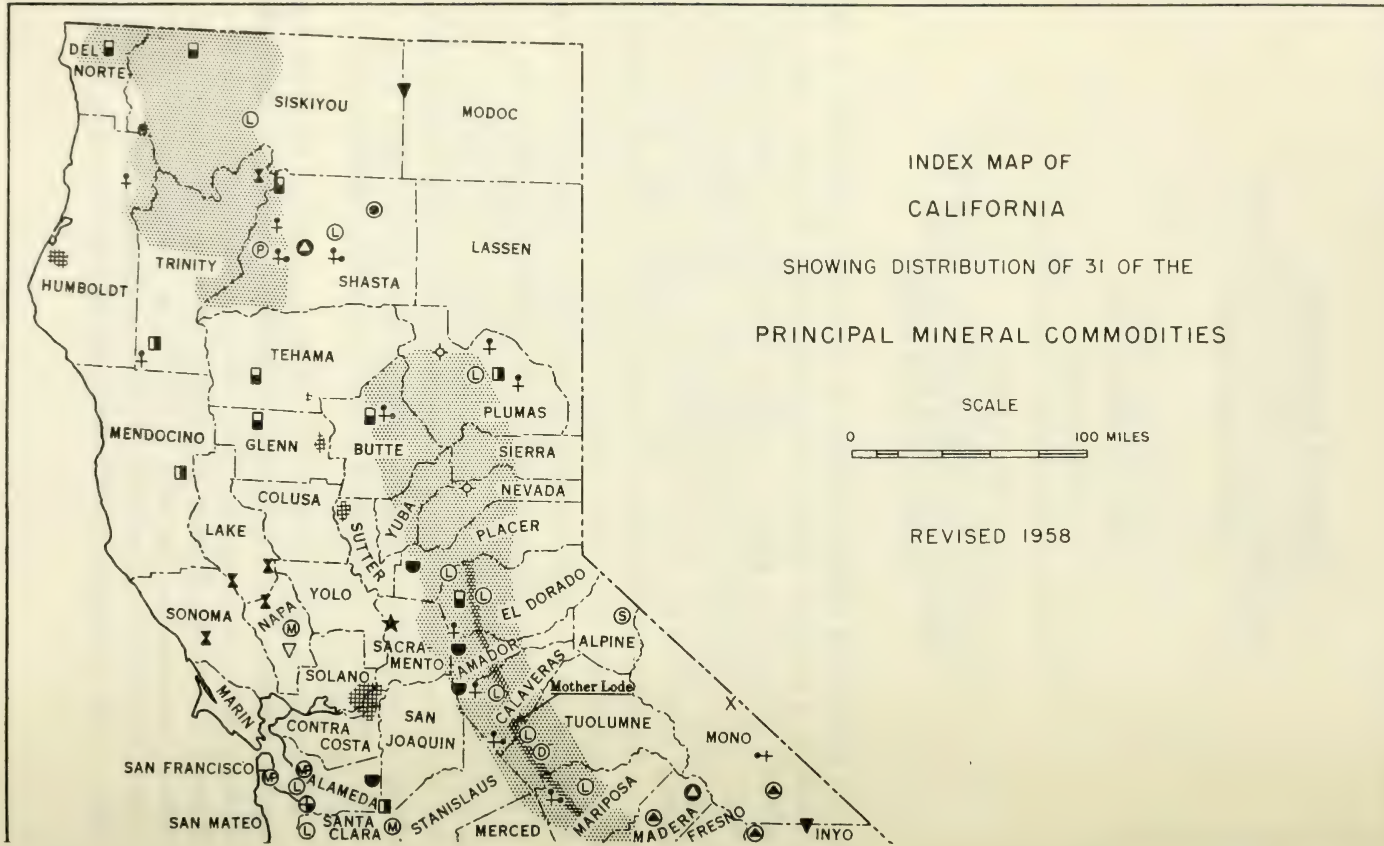
Headquarters
Third Floor, Ferry Building, San Francisco 11

Branch Offices
State Building, 217 West First Street, Los Angeles 12
Third Floor, State Office Bldg. 1, Sacramento 14
Department of Natural Resources Building
Cypress and Lanning, Redding

The Division of Mines maintains at its headquarters offices in San Francisco a technical library containing several thousand books and scientific journals on geology, mining, mineralogy, chemistry, metallurgy, and related subjects; a reading room containing periodicals devoted to the petroleum and mining industries, and newspapers from the mining centers of the state; exhibits of minerals, rocks, mine models, etc.; a service laboratory for the determination of California minerals; and a conference room with a mining engineer in attendance to serve the public and to sell publications of the Division. Publications are also sold at the Los Angeles, Sacramento, and Redding branch offices.

In addition to oral conferences in the offices of the Division of Mines, information concerning the mineral resources, mineral industry, geology, and mining operations of California is distributed to the public by means of publications, monthly releases, and letters. Each letter of inquiry received by the Division is answered by the technical staff member best qualified to do so.

The principal publications of the Division of Mines are **Bulletins**, **Special Reports**, and the quarterly **California Journal of Mines and Geology**, issued in January, April, July, and October of each year. **Mineral Information Service** is a monthly news release concerning the mineral resources and industry of California, designed to inform the public of discoveries, operations, markets, statistics, and new publications. A list of available publications will be sent free upon request.


INDEX MAP OF
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PRINCIPAL MINERAL COMMODITIES
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MENTO
AMADOR
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Mother Lode
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TUOLUMNE
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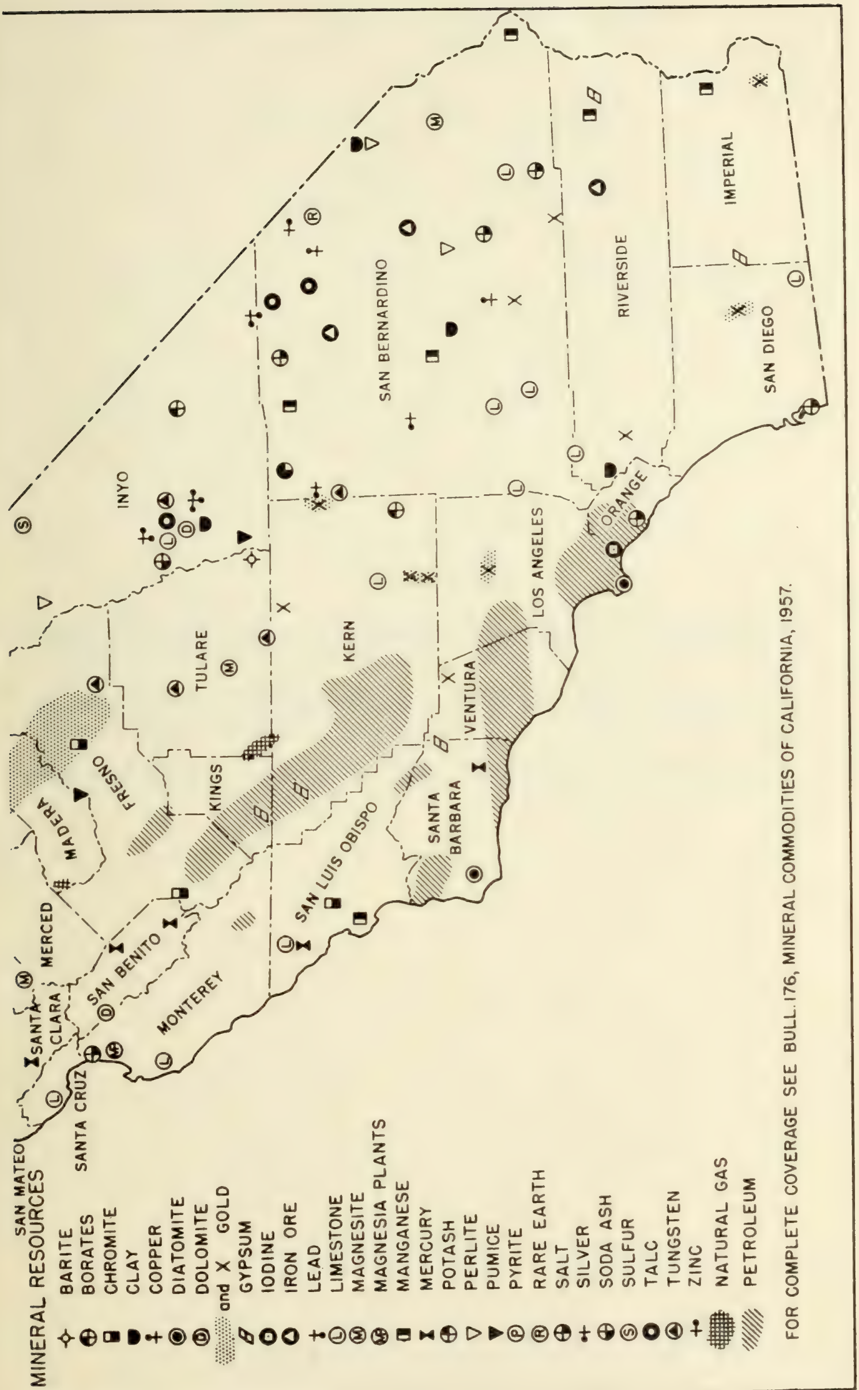

MINERAL RESOURCES
BARITE
BORATES
CHROMITE
CLAY
COPPER
DIATOMITE
DOLOMITE
and X GOLD
GYPSUM
IODINE
IRON ORE
LEAD
LIMESTONE
MAGNESITE
MAGNESIA PLANTS
MANGANESE
MERCURY
POTASH
PERLITE
PUMICE
PYRITE
RARE EARTH
SALT
SILVER
SODA ASH
SULFUR
TALC
TUNGSTEN
ZINC
NATURAL GAS
PETROLEUM
FOR COMPLETE COVERAGE SEE BULL. 176, MINERAL COMMODITIES OF CALIFORNIA, 1957.
SAN MATEO
SANTA CRUZ
SANTA CLARA
MERCED
SAN BENITO
MONTEREY
MADERA
FRESNO
KINGS
TULARE
INYO
SAN LUIS OBISPO
KERN
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IMPERIAL

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ANNUAL REPORT OF THE STATE MINERALOGIST CHIEF OF THE DIVISION OF MINES

for the 108th Fiscal Year July 1, 1956 to June 30, 1957

By Olaf P. Jenkins *

OUTLINE OF REPORT

Illustrations

* State Mineralogist and Chief of the Division of Mines, Department of Natural Resources.

LETTER OF TRANSMITTAL

Mr. DeWitt Nelson
Director, Department of Natural Resources
Sacramento, California

Sir: I have the honor to transmit herewith for reference to Governor Goodwin J. Knight the annual report of the State Mineralogist, Chief of the Division of Mines for the 108th fiscal year, July 1, 1956, to June 30, 1957. This is in accordance with the requirement in amended Section 2203 of the Public Resources Code. Sections of the Code are quoted throughout the report to give documentary evidence of what is required of the Division of Mines and to show that the Division's program adhered to the Code.

The activities of the Division are briefly summarized to show the scope and usefulness of the work accomplished. Results of this work are reflected in the expansion of California's industries which use raw mineral products mined in California. The Division has received praise and recognition from these industries for the assistance it has given in providing basic information on the geology and mineral deposits, mineral economics, mineral markets, and mineral development. The state's continued support of the Division of Mines and its recognition of the state's vast mineral wealth, productive and potential, is paying ample dividends to the people as shown in the value of the 1956 record of minerals produced, an all-time high of over one and a half billion dollars.

Respectfully submitted,

Olaf P. Jenkins
State Mineralogist and
Chief of the Division of Mines

Ferry Building, San Francisco
September 10, 1957

SUMMARY AND CONCLUSIONS

During 1956, for the first time in history, the value of the mineral production of California exceeded a billion and a half dollars—a 7 percent increase over 1955. For 6 consecutive years the mineral production has registered an all-time high, and for 9 successive years it has exceeded the 1 billion dollar mark.

This vast wealth may be attributed first to the mineral fuels—oil and gas (73.2 percent) ; second to the nonmetallic minerals (23.2 percent) ; and third to metallic minerals (3.6 percent). It is the decline in the production of some of the metallic minerals which brings forth the statement that mining is now in the doldrums; but the nonmetallic mineral industries are soaring to new heights, and for reasons of simple economics, the future for these useful commodities is exceedingly bright. Production of some of the metallics—iron, lead, zinc, and chrome—also increased.

The value of gold production dropped 23 percent because of the ever-rising cost of labor and materials, the fixed price, and strike conditions in one of the principal lode mines. Tungsten production dropped 13 percent because of decline in government purchases; mercury production also declined.

On the other hand, the production of borates, cement, diatomite, limestone, magnesium compounds, potassium salts, common salt, sand and gravel, sodium salts, and stone increased in quantity during 1956. This means new developments, new deposits, newly established processing plants, and new uses of mineral products. In the expansion of these industries and in the search for new deposits, the reports of the Division of Mines and the geologic maps issued by it have materially assisted the work of industry and encouraged, often initiated, new industry. The Division is of continuing service to the mineral industry of the state by supplying authoritative information which leads to the wise utilization of California's mineral and rock resources.

The state's investment in geologic study of its rocks and minerals pays off. The state could well afford to increase this investment in scientific study of basic facts, because it reaps the benefit in natural wealth for its people. Manufacturing increases the value of mineral raw materials many fold, because the raw minerals are made into more valuable products, many of which are used by every citizen every day he lives. The economic truth is, therefore, that with the expanding population of the state, manufacturing industries expand; in turn, new uses are found for minerals hitherto considered valueless; deposits previously exploited become still more useful, and the mining of them must be done on a larger scale and in more efficient ways.

Great strides have recently been made in scientific and engineering fields and greater progress is ahead. The Division of Mines must keep its personnel, equipment, and facilities in pace with these strides or it may become antiquated and left in the dust by modern economic advancement. At the same time, the Division must keep its feet on the ground and observe and map the rocks and minerals of that ground over the entire surface of the state. No square mile should be overlooked. No rock exposure should lie unobserved.

The fact that many other agencies in the state are also studying different phases of these interesting problems which have to do with the geology and mineral resources of the state makes it imperative that the Division of Mines acquaint itself with these agencies and their work, to cooperate with them with a view to advancing these studies, coordinating them, and making the useful information available to the people of California. In other words, the Division must be a living, growing, active agency, alert to the needs of industry, and able to produce up-to-date and informative information, which can be relied upon as being the unbiased truth in every case, free of selfish or political motives.

As the state becomes more populated, more areas become restricted for building sites, recreation, wild-life zones, parks, defense, etc., so that mineral and rock deposits which are becoming increasingly useful are also becoming more difficult to obtain and to secure permission to exploit. Withdrawal of areas from mining has already become a serious problem, and in the future we may find that areas accessible for mineral exploitation are very limited indeed. For these reasons, the exploitation of the nonmetallic mineral wealth of California may be seriously crippled if its importance is not thoroughly appreciated by all the people of the state.

Basic geological study is becoming increasingly useful in guiding building ventures, locating travel ways, bringing about a better understanding of earthquakes, marking the location and migration of underground water, as well as assisting in the enjoyment and useful understanding of our magnificent landscape. The Division has been called upon to report on the geology and mineral resources of the state parks, and to supply reports on the mineral potential of areas of proposed withdrawal. The most popular and sought-after of the Division's publications are those of general nature—guidebooks, histories, the evolution of the landscape, and all geologic and mineral maps.

Expenditures for the Division of Mines for the fiscal year 1956-57 amounted to approximately $545,747, an increase of 11.6 percent over 1955-56 that reflects only increased costs and service. From this amount is subtracted $16,731 collected from subscriptions for *Mineral Information Service*, making a net total of $529,015 spent for current support. Proceeds from sales of all other publications are deposited directly in the general fund; these sales amounted to $30,471 compared to $60,765 in the previous fiscal year. This reflects, in large part, a decline in monthly distribution of *Mineral Information Service* during the past year, from about 29,000 to 17,000. A charge for this publication, previously sent free, has brought about a material reduction in sale of the more technical and costly publications of the Division which supply most of the useful and detailed information requested by the mineral industry.

A certain number of all publications of the Division (about 2,000 per issue) is distributed without charge to libraries and on exchange; therefore, to recover a significant part of the printing costs, the sale must exceed 2,000, preferably 3,000 to 5,000 per issue. This can only be done by wide distribution of announcements together with feature stories concerning the significance of subject matter covered. *Mineral Information Service* carries these stories.

The personnel of the Division during fiscal 1956-57 comprised 56 employees, 33 technical (chiefly mining geologists) and 23 nontechnical. Four major phases of supervision are recognized: Mining engineering; geologic and commodity surveys; technical information services; and mineralogy, petrology, laboratory and exhibits. Headquarters of the Division is in the Ferry Building, San Francisco, where the library, laboratory, and exhibits are located. The San Francisco Bay area has always represented one of the greatest centers of mining activities and higher education, and now contains some of the principal offices of Federal bureaus of mines and geology.

Branch offices of the Division are located in Los Angeles, Sacramento, and Redding. The largest, in Los Angeles, is located in the State Building, 217 West First Street. The need for its services is ever increasing because of its position near expanding markets and large known and potential supplies of raw mineral products. The Sacramento office, in State Office Building No. 1, is in close proximity to the famous Sierra Nevada mineral field. The Redding office, in the Natural Resources Building, is near the Klamath Mountains, Cascade Mountains, and Modoc Plateau, and has vast potential mineral wealth to investigate. The branch offices and technical personnel are closely associated with Headquarters and carry on the work of the Division as a single body on the problems of the state. An example of such coordination is well exhibited in the forthcoming volume *Mineral Commodities of California,* Bulletin 176, to which all members of the staff contributed. In preparation of this treatise, each author has become a specialist on certain mineral commodities of which more than 60 are produced in the state and is therefore particularly well qualified to answer the public's questions about these commodities.

Serving the public consists of supplying authoritative information. This is best done, and with more permanent effect, by the preparation and distribution of published reports and maps that are generally sold at cost of printing, but supplied gratis to libraries and to other agencies on an exchange basis. Much information is also given to the public through correspondence, over the telephone, during interviews, and during public appearances. A total of 241 meetings was attended by members of the staff during fiscal 1956-57. Publications of the Division are often distributed at these meetings.

The Division issues several types of reports: (1) *California Journal of Mines and Geology,* a quarterly journal containing mineral inventories by counties, mineral statistics, and the annual report. (2) Bulletins, which are monographic in nature, such as *Minerals of California, Pumice in California,* etc. (3) Special Reports, which cover the results of special detailed investigations, such as the geology of the Casa Diablo Mountain quadrangle, Huntington Lake, and Bishop tungsten area. (4) *Mineral Information Service,* a monthly publication, printed by offset processes, in which information of occasional and particular interest is featured, such as announcements of new publications of the Division. This release is sent all over the world and has proved to be very useful, as shown by hundreds of complimentary letters received every month.

By far the most useful of all publications in developing new industries are the detailed geologic maps of areas and quadrangles which

are published by the Division. Gradually this work progresses, not only through efforts of staff members, but through work of cooperating agencies such as the Federal Geological Survey and the graduate departments of universities. There are dozens of quadrangle geologic maps involved. Index maps appearing in this annual report indicate the extent of all the quadrangle mapping and also the progress of the regional state map on the scale of 1: 250,000.

In preparing the state geologic map, the Division of Mines acts as a clearing house for all available data; the map will show, when completed, the major geologic formations of the entire state in 90 different colors and symbols. The individual sheets comprise areas two degrees east-west by one degree north-south, and will be distributed separately or assembled as a loose-leaf atlas of about 30 sheets in all. The geologic base will also be used in the preparation of economic maps which show the distribution of mineral deposits, and how this distribution is related to the geologic formations.

The policy of the Division to cooperate closely with all scientific agencies carrying on geologic work in California has resulted in the publication by the Division of many valuable reports, and also in the accumulation of a large backlog of yet unpublished reports, more than a score in number. The report of cooperation between the Division and the U.S. Geological Survey is attached to this annual report.

The library of the Division serves the public as well as the staff with a fine collection of technical reports on all subjects related to geology and mining. Over 21,000 volumes are available for consultation and many new books are placed on the shelves each year. Reading rooms serve anyone who wishes to use them. Periodicals on various subjects enable one to keep informed on all the latest developments and discoveries in the mineral field.

The mineral exhibits are also of long standing and are kept alive by reworking and by adding new donations. No better collection for study and convenience of observation exists in the West; there are 7,343 specimens on exhibit and new donations are coming in constantly. The exhibits were visited by 30,468 persons, of whom 4,873 were children, during fiscal 1956-57. The Division assists in training children to appreciate minerals by supplying elementary schools, on request, sets of minerals for study. A total of 314 sets of typical California minerals was sent free of charge to elementary schools during the fiscal year. The same staff member who attends to the mineral collection also makes periodic inspections and issues ore buyers' licenses; 34 limited and 22 unlimited licenses were issued in the fiscal year. The laboratory identified 5109 specimens of minerals for the public during the year; many of these were rocks difficult to determine without doing careful microscopic work. Some of the minerals were new to California.

The technical staff of the Division was very active during the fiscal year, especially on the assignment to complete Bulletin 176, *Mineral Commodities of California*, the subject matter of which covers many phases—geology, mining, mineralogy, processing, economics, markets, uses, and prices. In addition to the work in this volume which covers the general features in a statewide manner, staff members gave special continued detailed study to certain particular commodities such as limestone and dolomite, cement, micaceous ceramic materials, clay,

silica, sand, gravel, crushed rock, dimension stone, perlite, obsidian, fluorspar, nickeliferous laterite, jade, borax, peat, coal, and oil and gas. New techniques, such as biochemical prospecting, were included in the investigations. Special guidebooks for field excursions were prepared, such as one into the Ione clay area. Special reports on areas proposed to be withdrawn were prepared. Progress was made on county inventory reports, invaluable to a large number of local people. Reports on El Dorado and Mariposa Counties and the Alleghany-Downieville area were completed, and were published. Progress was made on Alameda, Calaveras, Contra Costa, Kern, Monterey, Orange, San Diego, and Trinity County investigations.

In conclusion, the program now being followed by the Division of Mines has proved to be entirely satisfactory and its continuance is therefore recommended. The investment by the state in all of this work has proved to be of great value because it has resulted in expansion of industry and in the wise utilization of the state's mineral resources. In order to keep in step with the increasing needs of an expanding population, the work of the Division should likewise be expanded. More geologic mapping should be done, on a more precise basis; the identification of minerals and analysis of samples should be expanded, both for the public and for the staff; modern analytical equipment should be purchased; and additional highly trained technical personnel should be employed to operate the equipment and carry on the program of the Division of Mines on the high level it is at present maintaining.

THE MINERAL WEALTH OF CALIFORNIA

Public Resources Code:

"2205. The State Mineralogist shall:

"(a) Make, facilitate, and encourage special studies of the mineral resources and mineral industries of the State.

"(b) Collect statistics concerning the occurrence and production of the economically important minerals and the methods pursued in making their valuable constituents available for commercial use.

"2207. The owner, lessor, lessee, agent, manager, or other person in charge of any mine of whatever kind or character within the State shall forward to the State Mineralogist, upon his request, at his office, not later than the thirty-first day of March in each year, upon forms which will be furnished, a report showing the character of the mine, the method of working the mine and the general condition thereof, and the total mineral production for the preceding calendar year. Any such person who fails to comply with the provisions of this section is guilty of a misdemeanor.

"Such reports shall be confidential. Other records are public records unless excepted by statute. Statistical bulletins based on these reports and published under the provisions of Section 2205 of this code shall be compiled to show, for the State as a whole and separately for each county, the total of each mineral produced therein, provided that, in order not to disclose the production of any operator, no production figure shall be published which represents the production of less than three operators; and when such production figure for any county would conflict with such provision it may be combined with such production figures for one or more other counties. Such bulletins shall be published annually by June 30th or as soon thereafter as practical."

The value of California mineral production continued to advance during 1956 and passed the billion and a half dollar mark for the first time in history. This advance is a direct reflection of the continued growth in population and industry, and the resultant demand for the

minerals essential in meeting the requirements of the expanding economy of the state.

The value of mineral production in 1956 was $1,556,554,392 (preliminary estimate), a 7 percent increase over the $1,458,729,633 value reported for 1955. Nineteen fifty-six was also the sixth consecutive year during which California mineral production registered an all time high.

Although the quantity of petroleum produced continued to decline slightly, unit price increases during the year placed the value of production slightly above the figure reported in 1955. The value of natural gas and natural gas liquids also increased.

Increases in the production of iron ore, lead, zinc, and chromite assisted in raising the value of production in the metals group of mineral commodities. Gold production dropped sharply (23 percent), a reflection of production and strike conditions at one large mine. A drop of 13 percent in value was reported for tungsten concentrates, a reflection of the decline in funds available for purchase under the U.S. Government stockpiling program. Mercury output also declined, as exploration and development received precedence over production.

In the industrial-saline group of minerals production was up and production facilities were greatly expanded. Borates, cement, diatomite, limestone, magnesium compounds, potassium salts, common salt, sand and gravel, sodium salts, and stone were all produced in increased quantities during 1956. The cement-plant capacity of the state was increased to about 8,000,000 barrels by new construction completed during the year. To serve these new plants three new limestone deposits were opened in southeastern California. An extensive new deposit of red-burning clay was discovered in southern California, and in the northern part of the state a large tunnel kiln was placed "on stream" for the production of heavy clay products.

A preliminary review of the 1956 mineral production is presented in the accompanying table.

California mineral production in 1956.

The value of mineral production during 1956 in California was $1,556,554,392 (preliminary estimate), an increase of nearly 7 percent over the 1955 figure of $1,458,729,633. The 1956 data tabulated below have been prepared by the U.S. Bureau of Mines in cooperation with the California Division of Mines.

Mineral commodity	Quantity 1956		Value 1956
METALS			
Chromite	27,082	short tons	$2,191,956
Copper	859	short tons	730,150
Gold	193,816	troy ounces	6,783,560
Iron ore	2,414,277	long tons	*
Lead	9,296	short tons	2,918,944
Manganese ore and concentrates			
35% + Mn	6,595	short tons	595,001
35% — Mn	293	short tons	19,630
Mercury	9,017	flasks	2,343,699
Silver	938,139	troy ounces	849,063
Tungsten concentrates	3,719	short tons	13,449,378
Zinc	8,049	short tons	2,205,426
Apportioned metals			$32,086,807
* Other metals (iron ore, molybdenum concentrates, platinum group metals, rare earth concentrates)			23,720,157
Total metals			$55,806,964

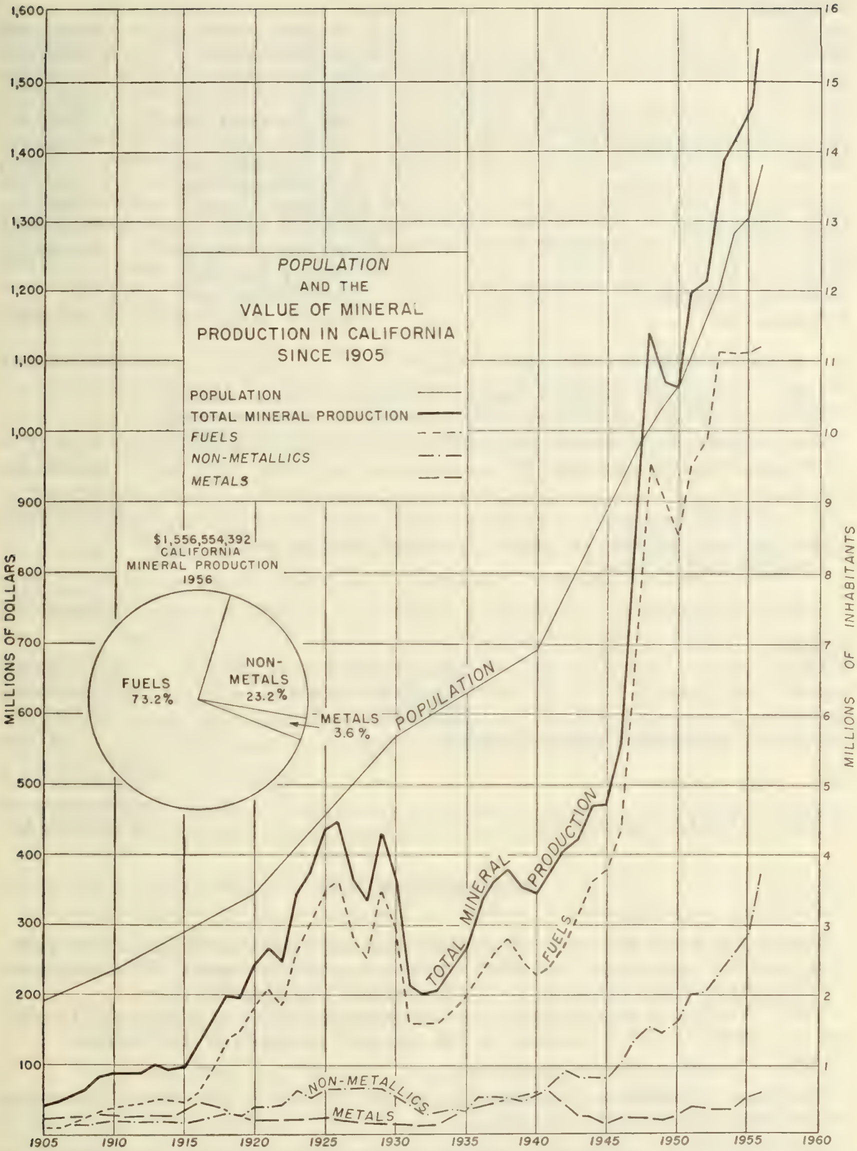

FIGURE 1. Graph showing growth in California population and mineral production since 1905.

NONMETALS			
Borates	944,950	short tons	39,591,953
Cement	39,289,586	barrels	120,511,049
Clays †	2,981,595	short tons	6,137,517
Gypsum	1,399,390	short tons	3,401,606
Lime	302,479	short tons	5,077,951
Magnesium compounds	66,007	short tons	4,531,777
Perlite	15,119	short tons	134,861
Pumice, volcanic cinders	634,356	short tons	2,333,809
Salt	1,444,211	short tons	7,605,764
Sand and gravel	86,525,955	short tons	96,776,212
Stone †	32,583,370	short tons	46,108,652
Sulfur ore	183,717	long tons	**
Sulfur (by-product)	146,808	long tons	**
Talc minerals	153,710	short tons	1,419,227
Apportioned nonmetals			$333,630,378
** Other nonmetals (asbestos, barite, bromine, calcium chloride, diatomite, feldspar, gemstones, iodine, magnesite, mica, potassium salts, pyrites, slate, sodium salts, sulfur ore, by-product sulfur)			
Unapportioned nonmetals **			45,279,431
Subtotal			$378,909,809
† Less clay sold or used in cement, limestone used in cement, and limestone used in lime			
Total nonmetals			$360,600,128
FUELS			
Natural gas	540,000,000	M cubic feet	$118,800,000
Natural gas liquids	31,430,000	barrels	129,000,000
Petroleum	352,000,000	barrels	892,000,000
Other fuels (coal, peat, carbon dioxide)			347,300
Total fuels (estimated)			$1,140,147,300
STATE TOTALS (preliminary)			$1,556,554,392

ADMINISTRATION

Public Resources Code:

"2201. The State Mineralogist shall employ competent geologists, field assistants, qualified specialists, and office employees when necessary in the execution of the plans and operations of the division under this chapter.

"2202. The State Mineralogist shall maintain offices, and a museum, library, and laboratory in San Francisco for the purposes provided in this chapter.

"2205. The State Mineralogist shall:

"(a) Make, facilitate, and encourage special studies of the mineral resources and mineral industries of the State.

"(g) Maintain, in effect, a bureau of information concerning the mineral industry of the State . . ."

"507.1. State Mining Board: Members: Appointment: Qualifications: Incumbent members: Filling vacancies: Confirmation of appointments: Organization: Powers: Appointment of employee of Division of Mines. There shall be a State Mining Board, consisting of five members appointed by the Governor with the advice and consent of the Senate for terms of four years and until their successors are appointed and qualified. Members shall be selected from those citizens of this State associated with or having detailed knowledge of the prospecting for, production, processing or marketing of the minerals of this State.

"The members of the incumbent Mining Board, continued in office, shall be classified by the Governor so that the terms of office of one member shall expire January 15, 1950, and the terms of two members on January 15, 1951, and Janu-

ary 15, 1952, respectively. An appointment to fill a vacancy occurring before the expiration of a term shall be only for the remainder of that term. All appointments made when the Legislature is not in session shall be subject to confirmation at the next regular or special session of the Legislature. The board shall have power to organize itself and select its officers.

"The board shall represent the State's interest in the development, utilization and conservation of the mineral resources of the State. It is empowered to establish policies conforming to the provisions of state statutes to govern the administration of the Division of Mines.

"The director may authorize the State Mineralogist to exercise his power to appoint employees of the Division of Mines in accordance with the State Civil Service Act. The director may authorize the State Mineralogist or any employee of the Division of Mines to exercise any power granted or perform any duty imposed upon the director by the State Civil Service Act. (Added by Stats. 1949, Ch. 1081, Sec. 2.)"

The Division of Mines is one of several divisions in the Department of Natural Resources. The headquarters of the Department and its Director are in Sacramento. The State Mining Board, consisting of five members appointed by the Governor, and serving without compensation, advises the Director and the Division of Mines on matters of policy.

The headquarters of the Division of Mines and its Chief, the State Mineralogist, are located in the south wing of the Ferry Building, San Francisco. The three branch offices, the largest in Los Angeles and smaller ones in Sacramento and Redding, extend services directly to the public. Administration, Editorial, Drafting, Library, and Laboratory are centered in the headquarters office in San Francisco. The Chief, Olaf P. Jenkins, is assisted in administration and operation of the Division by the Deputy Chief, Gordon B. Oakeshott.

Division administration and supervision are now organized to recognize four major phases or areas of Division work, each supervised by a Senior Mining Geologist:

MINING ENGINEERING, inventory of mineral resources by counties, mineral utilization surveys, and management of Division business—supervised by Richard M. Stewart.

TECHNICAL INFORMATION SERVICES, mining activities, mineral economics and statistics, and library—supervised by Fenelon F. Davis.

MINERALOGY, PETROLOGY, LABORATORY, AND EXHIBITS—supervised by Charles W. Chesterman.

GEOLOGIC AND COMMODITY SURVEYS, quadrangle and state mapping—supervised by Oliver E. Bowen, Jr.

At Los Angeles, Sacramento, and Redding are the branch offices which carry on the phases of Division work most effective and most needed in their respective parts of the state. Los Angeles, the largest, is headed by Supervising Mining Geologist Lauren A. Wright; Sacramento by Associate Mining Geologist William B. Clark; and Redding by District Mining Engineer John C. O'Brien.

In fiscal 1956-57 the Division of Mines staff comprised 56 employees —33 technical geologists and engineers, and 23 stenographic and other nontechnical employees. Technical positions of the Division of Mines are distinguished in state service by the classification of Mining Geologist: Supervising, Senior, Associate, Assistant, and Junior.

The Editorial section, which processes technical manuscripts for publication, is supervised by Public Information Officer Elisabeth L. Egenhoff. The Drafting section, headed by Supervising Geological

Draftsman Richard A. Crippen, Jr., prepares charts, maps, and illustrations for the publications. Librarian William A. Sansburn, is in charge of the Division's technical library which serves the public at the San Francisco headquarters office and also distributes sets of Division publications to public school teachers and students, and maintains a film lending library on the mineral industry.

A list of the technical staff of the Division of Mines as of June 30, 1957, with the major assignments and interests of each, follows:

SAN FRANCISCO HEADQUARTERS OFFICE

Olaf P. Jenkins, Chief, Division of Mines (State Mineralogist) Division administration. Direct supervision of the state geologic map project.

Gordon B. Oakeshott, Deputy Chief, Division of Mines; Division supervision; diatomite, graphite, petroleum; earthquakes and active faults.

Richard M. Stewart, Supervision of mining engineering section and Division business; county inventory reports; mineral utilization surveys; tungsten.

Charles W. Chesterman, Supervision of mineralogy-petrology section, laboratory, and exhibits; preparation of a bulletin on geology and mineral resources of Matterhorn Peak quadrangle; pumice, perlite, and obsidian; jade; fluorspar, cobalt.

Oliver E. Bowen, Jr., Supervision of geologic and commodity surveys; Monterey County, Monterey and El Portal quadrangles, Cherokee hydraulic pit; cement, limestone and dolomite.

Fenelon F. Davis, Supervision of technical information services; manganese and mercury; mining operations.

Henry H. Symons, Mineral economics and statistics; mining operations; technical information services.

Elisabeth L. Egenhoff, Supervision of Editorial section; technical editing; early history of mineral discovery and operations.

Mary H. Rice, Technical editing; early history of mineral discovery and operations; photography.

Richard A. Crippen, Jr., Supervision of drafting section; preparation of drafted illustrations.

William A. Sansburn, Library.

George L. Gary, Ore buyers' inspection; mineral exhibits.

Charles W. Jennings, Compilation of revision of new State geologic map sheets, scale: 1:250,000; coal and peat; preparation of a bulletin on geology and mineral resources of Hernandez Valley quadrangle.

William E. Ver Planck, Salines, gypsum, borates; silica resources. State economic mineral map.

Salem J. Rice, Report on reconnaissance geology of coastal area north of Eureka; serpentine and associated asbestos, chromite, and nickel.

Melvin C. Stinson, Uranium and rare-earth minerals; vanadium; uranium in Plumas County.

Earl W. Hart, Petroleum and natural gas; offshore oil.

Harold B. Goldman, Rock, sand and gravel; carbon dioxide; Alameda and Contra Costa counties.

Edmund W. Kiessling, Petroleum and natural gas; offshore oil.

Frederic R. Kelley, Clay and ceramic materials in northern California; Cretaceous stratigraphy of part of the southern Diablo Range.

F. Harold Weber, Technical information and laboratory services; San Diego County (transferred to Los Angeles office, September).

Rudolph Strand, Index to geologic mapping in California; assisting on State geologic map.

James B. Koenig, On military leave.

Robert A. Matthews, Laboratory and mineral exhibits.

LOS ANGELES OFFICE

Lauren A. Wright, Supervision; beryllium, calcite, feldspar, gemstones, kyanite, mica, pyrophyllite, talc; geology and mineral deposits of southern Death Valley.

Thomas E. Gay, Jr., Kern County report; ferro alloys, iron, rock, sand and gravel; geology of Coffee Creek area in Klamath Mountains.

Bennie W. Troxel, Kern and Imperial counties; abrasives, thorium, uranium in southern California, wollastonite; geology of Shadow Mountains.

Cliffton H. Gray, Jr., Geology of Corona quadrangle; dolomite, limestone, and tin; Orange County.

George B. Cleveland, Clay and ceramic materials; lateritic nickel in Sierran foothills; biogeochemical prospecting.

F. Harold Weber, San Diego County report; Anza-Borrego Park.

SACRAMENTO OFFICE

William B. Clark, Supervision; Calaveras County; gold and platinum; mining operations of the Sierra Nevada.

Philip A. Lydon, Calaveras County; geology of part of Mt. Abbot quadrangle in the Sierra Nevada; sulfur, titanium.

REDDING OFFICE

J. C. O'Brien, Trinity and Shasta counties; copper and zinc; mining operations of the northern counties.

FINANCIAL STATEMENT

The statement of expenditures for the fiscal year 1956-57 is approximate inasmuch as all bills for the year were not available for payment at the time this report was prepared. These approximate expenditures are compared below with actual expenditures for the years 1954-55 and 1955-56:

Expenditures 1954-55	$471,613
Expenditures 1955-56	488,761
	(3.6 percent increase over 54-55)
Expenditures 1956-57 (approx.)	545,747
	(11.6 percent increase over 55-56)

These increases reflect the increased costs of equipment, supplies, services, and wages, as well as the continuing need for the Division of Mines to provide more helpful and efficient services to the growing population in the state.

It should be noted that starting January 1, 1957, the distribution of the monthly publication *Mineral Information Service* was started on a subscription basis. Approximately 16,731 subscriptions (on a calendar year basis) were sold, and the funds so obtained were an abatement against the support expenditures for the Division.

ORE BUYERS' LICENSES AND INSPECTION

Public Resources Code:

"2250. It is unlawful for any person to engage in the business of milling, sampling, concentrating, reducing, refining, purchasing, or receiving for sale, ores, concentrates, or amalgams bearing gold or silver, gold dust, gold or silver bullion, nuggets, or specimens without first procuring the license provided for by this chapter.

"2253. The application for a license to carry on such business shall be made to the State Mineralogist . . .

"2267. Every licensee under this chapter shall file monthly with the State Mineralogist a report of all purchases made under this chapter. The reports shall be made upon forms prescribed by the State Mineralogist and shall contain the information required by this chapter."

Fifty-six ore buyers' licenses were issued by the Division of Mines during the fiscal year. Thirty-four licenses were limited (limiting buyer to $1,000 in purchases during the calendar year), and 22 licenses were unlimited (without limit on purchases). Sixty-one licenses were issued by the Division during the previous fiscal year.

EXPENDITURES

Fiscal 1955-56 *

Total salaries and wages		$330,507.87
Operating expenses:		
Freight, cartage and express	$917.96	
Telephone and telegraph	3,225.41	
Toll calls	556.65	
Light, heat, power	2,341.51	
Rent of building space	31,052.40	
Repairs and maintenance	502.04	
Office supplies and services	4,617.51	
Postage	12,420.31	
Photography supplies and services	1,253.25	
Blueprinting	594.36	
Printing bulletins and maps	69,702.03	
Printing, general	2,036,32	
Technical reports	4,900.00	
Auto operations—parts, services, gas, oil, tires, tubes	6,746.46	
Travel	15,456.77	
Auto mileage	308.01	
Laboratory supplies and services	4,262.70	
Premiums on bonds	78.98	
Library supplies and services	927.67	
Exhibits supplies and services	234.86	
Total operating expenses		$162,135.20
Equipment:		
Automobile	$4,952.85	
Laboratory	2,218.79	
Office	8,186.10	
Miscellaneous replacements	153.14	
Miscellaneous additional	1,199.22	
Library	1,393.58	
Total equipment		$18,103.68
Total expenditures		$510,746.75
Special item: Geological exploration in cooperation with U. S. Geological Survey		35,000.00
Grand total		$545,746.75
Appropriation reimbursement: Sale of Mineral Information Service		$16,731.00
Grand net total, current operations		$529,015.75

* Some of the figures given are approximate, because not all bills for the fiscal year were paid at the time this report was prepared.

All licensees' records and transactions were inspected and checked to insure compliance with the law. Cooperation with local, state, and federal agencies in the investigation of suspected illegal transactions and illicit traffic in gold continued during the year.

PUBLIC INFORMATION SERVICE

Public Resources Code:

"2202. The State Mineralogist shall maintain offices and a museum, library, and laboratory in San Francisco for the purposes provided in this chapter.

"2205. The State Mineralogist shall:

". . . (g) Maintain, in effect, a bureau of information concerning the mineral industry of this state . . ."

Where is the best place to prospect for chromite? Will you help me interpret this spectrographic analysis of my ore? How do I get mercury out of cinnabar? Where can limestone from my deposit be used to best advantage? These are samples of the questions continually asked the Division of Mines by the mining public. The questions are received in correspondence and over the telephone or are presented in person by visitors to our information offices at San Francisco, Los Angeles, Sacramento, and Redding.

When it is remembered that more than 60 mineral commodities are produced commercially and many others are sought after in California, some idea can be obtained of the range and diversity of questions answered by the Division's Information Section.

Furthermore, when mining or mineral topics are presented in some of the popular magazines of wide circulation, the Division is almost immediately flooded with questions for additional details and for circulars and reports on the subject of the article. The public is also very sensitive to 'spot' radio and television announcements on mining topics and the immediate reaction is to seek additional details from the Division of Mines. In addition, there is the continually increasing demand for geologic maps, geologic reports, mining activity reports and the processing of minerals from experienced mining engineers and all parts of the established section of the mining industry.

As a result of these contacts with the mining public new businesses are frequently established and the mineral wealth of the State of California is utilized to a greater degree. Typical examples of assistance rendered through our Public Information Services during the fiscal year 1956-57 are assembled, classified and summarized in the following paragraphs.

Basic Geologic Data

Supplied mining company officials with data on geology of their mineral deposit. Supplied a geologist of the Nevada Bureau of Mines with information on antimony deposits in California. Conferred with mining company officials regarding fluorspar properties in Inyo County. Directed a research company to an area for study of mercury deposits. Gave sketch of a base metal district in the southern Sierra Nevada to a mining company. Gave information on a copper prospect to a mining consultant. Submitted a geologic report and reconnaissance geologic map to the State Forester on an area in Tulare County.

Supplied information on limestone and dolomite in Standard quadrangle to a company geologist. Supplied information on bituminous sandstone in California to an oil company representative. Furnished a land lessor with information on California gas fields. Supplied stratigraphic information to a person planning to drill an exploratory well in Kern County. Provided U. S. G. S. geologists with geologic map data for new tectonic and plutonic rock maps. Assisted U.S. Forest officer to find geologic data for an area in southern California. Informed a German geologist on the geology of California steam wells.

Furnished information on Ione sand to New York investment banking firm. Answered inquiries on index fossils and stratigraphic terms. Advised an engineer on characteristics and location of Hayward fault, in relation to Naval Hospital building program. Discussed serpentine

and related mineral deposits with visiting government geologist from Greece. Assisted Department of Water Resources geologist with geological information on Lake County. Provided company representative with information on epsomite deposits. Discussed possibilities for zirconium and hafnium in California with a consulting geologist. Provided insurance company engineer with references on landslides. Assisted persons interested in geochemical prospecting. Discussed with a contractor problems and preventative measures involved in subdividing land subject to landslides. Assisted consultant with problems of developing limestone deposit for cement manufacture. Assisted Division of Lands engineers with data on talc, clay, and uranium deposits in connection with proposed mineral leases. Discussed with a representative the possible sources of raw material for a chemical plant. Prepared a report on geology of Poe Tunnel for Department of Water Resources.

Suggested areas suitable for airbourne magnetometer survey for iron.

Sources of Raw Material

Supplied eastern mining firms with data on fluorspar and perlite resources of California. Informed Military Geology branch of U.S. Geological Survey on availability of construction materials in the Santa Lucia Range, Monterey County. Advised Division of Highways on the gravel potential along the Russian River north of Healdsburg. Furnished information on California aggregates to U.S. Government geologist. Directed a member of Australian Geologic Survey to areas of reactive concrete aggregate in the state. Furnished a company representative with data on a sand deposit in Contra Costa County. Advised an eastern sand company on the possibility of using certain creek gravels for concrete aggregate.

Directed a prospective producer to sources of aggregate in Santa Clara Valley. Directed a Division of Water Resources geologist to source of aggregate in Bay Area for a proposed canal route. Discussed possible sources of riprap in Bay Area with a construction company. Advised a consulting geologist on the occurrence of carbon dioxide in California. Directed a construction company to a source of crushed rock of a specific type, and to a source of heavy aggregate for high density concrete. Assisted a planning consultant in determining the potential of the oil and gas industry in Lassen, Yuba, and Ventura Counties.

Outlined nickel possibilities in California for geologists of numerous large eastern mining companies. Provided information on salt, soda and borates to an interested company. Discussed materials suitable as absorbents for pet sand boxes with a local manufacturer. Informed County Road Department of occurrences of rhyolite for test purposes. Suggested sources of rock for ornamental stone to supplier.

Mining and Mineral Processing Data

Assisted the Mining World in compiling a Directory of United States mining operations for their yearbook. Aided U.S. Bureau of Mines personnel in analyzing production returns from rock producers. Determined amount of sand mined from beach areas by commercial operators for sedimentation study by U. C. professor. Helped consultant

evaluate gas showings in northern California with reference to encountering gas in tunneling. Provided research geologist with information on lignite and coal in California. Supplied information on location of Hoffman kilns in California to kiln equipment manufacturer. Discussed nickel prospect with owner.

Discussed rail haulage equipment in and about mines with a man planning to build a model railroad based on a mining operation. Provided data on potential users of hydraulic mining equipment to manufacturer. Supplied data on drift mines in Placer County to U.S. Bureau of Reclamation. Supplied state assemblyman with data on mining claims. Correlated geology of Poe Tunnel with tunnel-driving rates. Advised gold miner on sampling methods. Discussed a mining engineer's report with an investor. Referred owner of idle chrome mill to mine operators requiring such equipment.

Mineral Utilization and Marketing

Supplied potential consumer of expanded perlite with information on the uses and markets. Advised quarry owner on market for dimension stone and roofing granules. Informed Stanford Research Institute on movement of sand and gravel into northern California area by rail. Furnished information on quality of aggregate in northern California to a potential producer. Advised mining company geologist on the production and utilization of antimony. Provided information on requirements, uses and marketing of limestone. Advised owner on possible outlet for bentonite. Advised mining company on disposition of clay by-product. Informed potential buyer on clay resources of Tesla area. Informed clay deposit owner on requirements for raw materials needed in aluminum industry. Advised buyer on availability of diaspore, hectorite and halloysite in the state.

Explained the marketing of gypsum to owner of a large deposit. Gave operator of an iron mine marketing data on heavy aggregate. Discussed economics of pumice and perlite with owners of deposits. Provided owner of optical quartz deposit with marketing and buyers information. Informed discoverer of talc deposit on marketing situation.

Chemical and Physical Data on Rocks and Minerals

Supplied petrographic descriptions of commercial aggregate to a concrete laboratory. Furnished information on petrography of Niles Cone aggregate to a materials laboratory. Analyzed placer material for a mine owner to determine possible value of black sand constituents. Gave data on sodium sulfide leaching process to a geochemical company setting up a pilot plant for mercury ores. Advised utility company engineer on the nature of turbidity in water samples. Made firing experiments on clay proposed as raw material for brick plant. Identified rocks for a soil scientist of the U.S. Dept. of Agriculture. Identified as chromite a heavy mineral which was troubling an operator in his attempt to concentrate cinnabar.

Prepared a suite of specimens illustrating raw materials of sand blasting for a convention at Hunters Point shipyard. Furnished sample of nickeliferous laterite to a smelting company for treatment tests. Made tentative identification of well cutting. Collected, examined and reported on the mineral content of specific beach sands for

the Division of Beaches and Parks. Identified minerals in a cement additive for an importer.

Miscellaneous Services

Appeared at a hearing at Martinez concerning quarry sites in the Orinda district of Contra Costa County. Assisted a research technician studying the use of the petrographic microscope. Advised County Civilian Defense Offices of maps showing active faults, for disaster planning. Aided appraiser in evaluating clay deposit in condemnation proceedings. Provided technical information on cyanide process for scenario writer. Suggested areas suitable for geologic mapping to graduate students. Assisted investors with information on rare earths. Assisted miners seeking employment by providing lists of operating mines. Suggested engineers and geologists for consulting jobs.

Assisted authors writing historical mining articles and reviewed their work. Discussed employment opportunities in mining with Department of Employment representative. Assisted with many of the county mining exhibits at the state and county fairs.

List of Public Appearances

Attended and participated in a total of 241 meetings, conferences, mineral shows. Gave 36 talks; at 14 events, publications were sold, worth nearly $700. At the fairs and mineral shows, staff members gave information on minerals and mining, identified minerals, exhibited mineral specimens and Division of Mines publications.

Technical groups

American Association of Petroleum Geologists: Attended Pacific Section annual meeting; two forum meetings; lecture at Stanford; National Convention in St. Louis—displayed maps and publications, consulted with state and petroleum geologists.

American Institute of Mining, Metallurgical, and Petroleum Engineers: Attended meetings of Mining Branch, northern and southern California; Northwest Regional Meeting, Portland; Regional Reactive Metals Conference (served on planning committee); National Petroleum Branch (presided at dinner meeting); Southern California Section (served on program committee; presided at committee meetings and Board of Directors meeting); Pacific Southwest Industrial Minerals Conference, Reno—served on planning committee, attended technical sessions, presented paper on mineral resources of Ione formation, consulted with mining geologists.

American Mining Congress: Attended technical sessions and field trips; served on program committee.

Association of American State Geologists: Served as Acting President.

California Academy of Sciences: Attended lectures; presented a lecture.

Clays and Clay Technology Committee: Attended meetings; assisted in planning program for 1957 National Clay Conference.

Geological Society of America, Cordilleran Section: Presented papers on structural features of the south Amargosa Valley; geology of Corona South quadrangle; biogeochemical prospecting for molybdenum; geology of Mt. Abbot quadrangle; pre-Cambrian granulite. Displayed newly prepared portions of state geologic map. Conferred with geologists.

Mining Association of Southern California.

Stanford University Committee on Cretaceous of California: Participated as member of board of consultants.

XX International Geological Congress, Mexico City: Attended technical sessions; presented paper on volcanic lightweight aggregates of western United States.

Chambers of Commerce

Los Angeles Chamber of Commerce: Attended Mining Committee meetings; subcommittee on mining equipment; Prospectors Institute (gave talk).
Mono County Chamber of Commerce, joint meeting with State Mining Board: Geologists of Division of Mines gave panel presentation on mines, mineral resources, and geology of eastern side of the Sierra Nevada.
Redding Chamber of Commerce, joint meeting with State Mining Board: Division geologists presented panel discussion on the mineral resources of northern California.
San Francisco Chamber of Commerce: Attended Mining Committee meetings and meeting on gold. At Chemical and Mining Industries Conference, gave talk and represented Division of Mines on panel presentation.
Tuolumne County Chamber of Commerce: Gave talk on the mineral resources of the central Sierra Nevada.

Conferences and hearings

Bureau of Land Management hearing concerning legislative changes for disposing of public domain.
Governor's Advisory Committee on Peacetime Use of Radiological Materials.
Interagency Management Conference: Participated in 1956 and 1957 meetings.
Ione Valley Dam site: Participated in conference of federal, state, and industry representatives on effects of the proposed Ione dam on the clay resources of that area.
Land Subsidence Committee.
Martinez hearing concerning quarry sites in Orinda district.
San Francisco earthquake: Cooperative meeting with U.S. Coast and Geodetic Survey, U.S. Geological Survey Engineering Branch, and Pacific Fire Rating Bureau.
Tungsten Producers Conference and hearing before House of Representatives subcommittee.
University of California conference on engineering geology problems of water.
Water Resources Board.

Fairs and mineral shows

California State Fair: Set up Division of Mines exhibit; distributed publications; assisted in judging mineral displays.
Castro Valley Gem and Mineral Society
Humboldt Gem and Mineral Show
Monterey Bay Mineral Show
Napa County Rock and Gem Club Show
Rand District Old Time Mining Celebration
Redwood Empire Gem Show
Sacramento Mineral Show: Read and graded papers on earth sciences by junior members participating in contest.
San Bernardino County Fair
Santa Clara Valley Gem and Mineral Society Show
San Luis Obispo Gem and Mineral Society Show
San Mateo Gem and Mineral Society, 8th annual exhibition
Shasta Gem and Mineral Show
Sonoma County Fair
Stockton Gem and Mineral Show

Mineral and Geological Societies

Coalinga Rockhounds
East Bay Mineral Society
Journal Club, Stanford Geology Department
LeConte Geological Club
Los Angeles Mineral Society
Marin Gem and Mineral Society
Mineral Association of Northern California
Mother Lode Mining Society
Northern California Geological Society
Oakland Gem and Mineral Society
Pacific Mineral Society
Peninsula Geological Society

Palo Alto Geological Society
Sacramento Geological Society
San Joaquin Valley Geological Society
Santa Clara Gem and Mineral Society
Standard Oil Rockhounds
Society of Economic Paleontologists and Mineralogists
Vallejo Gem and Mineral Society

Educational

Association of Geology Teachers, Far Western Section: Arranged and led program of annual convention. Acted as vice-president and program chairman. At San Jose meeting, gave talk on teaching aids of the Division of Mines.
Alameda County high school students: Participated in counselling panel.
Cal-Tech Geology Club
Contra Costa County teachers group
County Librarians conference in Bakersfield: Discussed Division of Mines publications and service to libraries.
Marin County Junior Museum: Led field trip to Tiburon Peninsula
Eureka school principals meeting
San Francisco Adult School: Spoke to two lapidary classes
Santa Monica City College
Stanford University, School of Mineral Sciences, Open House

Miscellaneous

American Photogrammetric Society
Commonwealth Club, Mineral Industries Committee
Larkspur-Corte Madera recreation group: Led field trip to Tiburon lawsonite-eclogite locality
Mill Valley Rotary Club
Presbyterian Men's Club, Vallejo
Sierra Club
U. S. Naval Reserve unit
Western Mining Council, Shasta and Trinity Chapters

Topics of talks

Maps
History of mining in Redding area
Faults and earthquakes
Jade mining at Leech Lake Mountain
Minerals from California mines
Prospecting for industrial minerals
California mineral industry
Quartz family minerals
Jade in California
Geology as a profession
Mineral collecting in Bay area
Death Valley geology
Teaching aids of Division of Mines
Progress of revised state geologic map
Manganese and pyrite in northern California
Dimension stone in California
Uranium in California
Mineral resources of central Sierra Nevada
Serpentine and associated minerals
Geological journeys in the San Francisco Bay area
Geology and mineral deposits of Mother Lode area

PUBLICATIONS OF THE DIVISION OF MINES

Most of the reports processed by the Division's editorial section during the current fiscal year were prepared by the Division's staff members, in contrast with the number of contributions from outside sources previously. Bulletin 176, *Mineral Commodities of California,* represented the major project, publication of the results of which will appear

in fiscal 1957-58. *Bulletin 176* and *Mineral Information Service* consumed at least three-quarters of the time of the editorial section during the fiscal year.

This section serves also as a clearing-house for photographs of the Division, for the most part used in publications. In some cases, special photography for the Division has been done by this section.

The following is a list of *Publications Issued during Fiscal Year 1956-57*, and a list of *Publications in Press at Close of Fiscal Year 1956-57*. In these lists, the few articles not prepared by Division of Mines' staff members have been designated by one of three symbols in parenthesis after the name of the author:

(GS) Prepared by a member of the U. S. Geological Survey
(U) Prepared by a member of a university faculty or graduate student
(C) Prepared by a consultant or member of a commercial firm.

Publications Issued During Fiscal Year 1956-57

Mineral Information Service

Vol. 9, No. 7, July 1956: Lead and zinc in California; Announcement of new publications; New list of exploratory holes and revised oil and gas map; Basic studies in the clay industry—new symposium of clay fabrication; Mineral marketing; Mineral news notes.

Vol. 9, No. 8, August 1956: The mineral resources of the Ione formation; U.S. Geological Survey office moves; "Rock Club Manual" released; "Evolution of the Igneous Rocks" reprinted; New book on microfossils; Rock products in Contra Costa; Geologic map of California; Mineral marketing information.

Vol. 9, No. 9, September 1956: Lithium compounds; Fire flooding; Time limit on chrome purchasing program extended; New purchase program for tungsten; Surface rights to unpatented mining claims; Operating data on mercury mines.

Vol. 9, No. 10, October 1956: American Mining Congress to meet; Gold; A.I.M.E. meeting; General Warren T. Hannum; New director for U.S.B.M.; A.A.P.G. meeting; New tungsten price schedule; New highways to use California mineral products; New addresses; New report on Sierra; Subscribers . . .; Southwest mineral conference.

Vol. 9, No. 11, November 1956: Talc; Public law 167 and surface rights on unpatented mining claims; Mineral market quotations; Chemical and mining interindustry conference; Cement output increased; Notice to subscribers.

Vol. 9, No. 12, December 1956: Peat; New book on atomic minerals; Index to volume 9; Concrete tetrapods.

Vol. 10, No. 1, January 1957: Pumice, pumicite, and volcanic cinders in California; California topographic maps; Events in California mineral production, 1956; Folio of Jurassic system; New map of desert; New edition of "Minerals of California."

Vol. 10, No. 2, February 1957: California mineral production, 1956; California topographic maps; Events in California mineral production, 1956; Folio of Jurassic system; New map of desert; New edition of "Minerals of California."

Vol. 10, No. 3, March 1957: Minerals of California; Aggregate for new highways; New quicksilver plant in San Mateo County; International Mineral Dressing Congress; California petroleum 1956; New revised edition of "Minerals of California."

Vol. 10, No. 4, April 1957: Commercial silica; Guadalupe mine increases production.

Vol. 10, No. 5, May 1957: San Francisco earthquake of March 22, 1957; Scheelite crystal discovery; Sixth clay conference; Mineral law.

Vol. 10, No. 6, June 1957: Rare earth elements (C); Company will test rare-earth ores for prospectors; U.S. Geological Survey releases logs of cores in desert; Change in price of topographic maps; New issue of Minerals Yearbook by U.S. Bureau of Mines; New offshore platform drilling near Summerland; Journal to be late; U.S.G.S. exploring desert borates; Sixth Commonwealth mining tours; Proceedings of World Conference on Earthquake Engineering now on sale.

California Journal of Mines and Geology

Vol. 52, No. 4, October 1956: Annual report of the State Mineralogist, by Olaf P. Jenkins; Mines and mineral resources of El Dorado County, California, by William B. Clark and Denton W. Carlson; National minerals policy; Index to volume 52.

Bulletins

Bulletin 173, Minerals of California, by Joseph Murdoch (U) and Robert W. Webb (U).

Bulletin 174, Pumice, pumicite and volcanic cinders in California, by Charles W. Chesterman, containing an article entitled Technology of pumice, pumicite, and volcanic cinders, by F. Sommer Schmidt (C).

Special Reports

Special Report 46, Geology of the Huntington Lake area, Fresno County, California, by Warren B. Hamilton (U).

Special Report 47, Economic geology of the Bishop tungsten district, California, by Paul C. Bateman (GS), with a section on the Pine Creek mine, by Paul C. Bateman and Lawson A. Wright (C).

Special Report 48, Economic geology of the Casa Diablo Mountain quadrangle, California, by C. Dean Rinehart (GS) and Donald C. Ross (GS).

Publications in Press at Close of Fiscal Year 1956-57

Mineral Information Service

Vol. 10, No. 7, July 1957: Aluminum; Mercury purchase program extended; Dimension stone production increasing; New reports on Bishop district.

California Journal of Mines and Geology

Vol. 53, Nos. 1-2, January-April 1957: Geology of the Island Mountain copper-pyrite mine, Trinity County, California, by Melvin C. Stinson; Mines and mineral deposits of Mariposa County, California, by Oliver E. Bowen Jr. and Cliffton H. Gray Jr.

Vol. 53, Nos. 3-4, July-October 1957: Lead and zinc in California, by J. Grant Goodwin, including Economic mineral map of California No. 7—lead and zinc; Index to volume 53.

Bulletins

Bulletin 175, Salt in California, by William E. Ver Planck.

Bulletin 176, Mineral commodities of California, containing: Natural environment of the mineral resources of California, by Olaf P. Jenkins; Abrasives, by Bennie W. Troxel; Aluminum, by George B. Cleveland; Antimony, by Harold B. Goldman; Arsenic, by J. Grant Goodwin; Asbestos, by Salem J. Rice; Asphalt and bituminous rock, by Charles W. Jennings; Barite, by Charles J. Kundert; Beryllium, by Lauren A. Wright; Bismuth, by Charles W. Chesterman; Black sands, by Melvin C. Stinson; Boron, by William E. Ver Planck; Bromine, by William E. Ver Planck; Cadmium, by J. Grant Goodwin; Calcite (optical grade), by Lauren A. Wright; Calcium chloride, by William E. Ver Planck; Carbon dioxide, by Harold B. Goldman; Cement, by Oliver E. Bowen Jr.; Chromite, by Salem J. Rice; Clay, by George B. Cleveland; Coal, by Charles W. Jennings; Cobalt, by Charles W. Chesterman; Copper, by J. C. O'Brien; Diatomite, by Gordon B. Oakeshott; Feldspar, by Lauren A. Wright; Fluorspar, by Charles W. Chesterman; Gem stones, by Lauren A. Wright; Gold, by William B. Clark; Graphite, by Gordon B. Oakeshott; Gypsum, by William E. Ver Planck; Iodine, by William E. Ver Planck; Iron industries, by Thomas E. Gay Jr.; Kyanite, andalusite, and related minerals, by Lauren A. Wright; Lead, by Richard M. Stewart; Limestone, dolomite, and lime products, by Oliver E. Bowen Jr.; Lithium and lithium compounds, by William E. Ver Planck; Magnesium and magnesium compounds, by William E. Ver Planck; Manganese, by Fenelon F. Davis; Mercury, by Fenelon F. Davis; Mica by Lauren A. Wright; Minor metals, by J. Grant Goodwin; Molybdenum, by Richard M. Stewart; Natural gas, by Earl W. Hart; Natural gas liquids, by Earl W. Hart; Nickel, by Salem J. Rice; Nitrogen compounds, by William E. Ver Planck; Peat, by Charles W. Jennings; Petroleum, by Charles W. Jennings; Phosphates, by Charles J. Kundert; Platinum and allied metals, by William B. Clark; Pumice, pumicite, and volcanic cinders, by Charles W. Chesterman; Pyrites, by Charles W. Chesterman;

Pyrophyllite, by Lauren A. Wright; Quartz crystal (electronic grade), by Lauren A. Wright; Quartzite and quartz, by William B. Clark and Denton W. Carlson; Rare earth elements, by Lloyd C. Pray (C); Salines, by William E. Ver Planck; Salt, by William E. Ver Planck; Sand and gravel, by Thomas E. Gay, Jr.; Shale, expansible, by B. H. Rogers and Charles W. Chesterman; Silver, by Richard M. Stewart; Sodium carbonate, by William E. Ver Planck; Sodium sulfate, by William E. Ver Planck; Specialty sands, by Thomas E. Gay Jr.; Stone, crushed and broken, by Thomas E. Gay Jr.; Stone, dimension, by Harold B. Goldman; Strontium minerals, by William E. Ver Planck; Sulfur and sulfuric acid, by Philip A. Lydon; Talc and soapstone, by Lauren A. Wright; Thorium, by Bennie W. Troxel; Tin, by Cliffton H. Gray Jr.; Titanium, by Philip A. Lydon; Tungsten, by Richard M. Stewart; Uranium, by Bennie W. Troxel, Melvin C. Stinson, and Charles W. Chesterman; Vanadium, by Melvin C. Stinson; Wollastonite, by Bennie W. Troxel; Zinc, by J. C. O'Brien; Zirconium and hafnium, by Melvin C. Stinson; Index.

INVENTORIES OF MINING ACTIVITIES

Public Resources Code:

"2208. The State Mineralogist or a qualified assistant may at any time enter or examine any and all mines, quarries, wells, mills, reduction works, refining works, and other mineral properties or working plants in this State in order to gather data to comply with the provisions of this chapter."

One of the most important functions of the Division of Mines is to maintain an inventory of the mineral resources of the state and a record of the mining activities in connection with these resources. Changing economic conditions and changes in the state's industrial pattern cause greater or less emphasis to be placed on individual mineral commodities. Therefore, up-to-date inventory reports assume added importance.

Inventory surveys are published as county reports, which summarize all pertinent information on a county's mineral resources, including ownership of the individual reposits, nature of the deposits, history of the mining operations and current status. Photographs, charts, mine maps, planimetric maps of the county showing locations of mineral deposits, and geologic maps assist in the presentation of the facts. The county report is one of the most commonly requested types of Division of Mines publications.

County reports are published in the quarterly *California Journal of Mines and Geology.* News items and shorter reviews of mining activities are published in *Mineral Information Service.* Occasionally more detailed studies of mineralized districts are required. These may be published in the *Journal,* or in the *Special Report* or the *Bulletin* series.

During the fiscal year 1956-57, reports on El Dorado and Mariposa Counties and a report on the lode gold mines of the Alleghany-Downieville area, Sierra County, were published in the *California Journal of Mines and Geology.* Reports on Shasta and Tulare Counties were completed and were being reviewed and edited for early publication. Assignments were made and work was in progress for reports on Alameda, Calaveras, Contra Costa, Kern, Monterey, Orange, San Diego, and Trinity Counties.

Mineral Information Service during the year contained articles on mineral resources of the Ione formation (August 1956), a new quicksilver plant in San Mateo County (March 1957), the Guadalupe mine

(April 1957) and a scheelite crystal discovery at Tyler Creek tungsten mine in Tulare County (May 1957).

Progress made by staff members on county inventory reports is summarized below:

Alameda County—Preliminary review of published material was started. The sand and gravel industry was studied.

Calaveras County—Data were obtained on nearly 1,000 mineral properties by reviewing old publications, including the Mining and Scientific Press. More than 50 properties were checked in the field, and County records were examined.

Contra Costa County—All sources of crushed rocks and specialty sands in the county have been checked in the field. Literature was reviewed and a tabulation of all mineral deposits started.

Kern County—A card index on the various mining properties in the county, showing previous references to these properties, was completed. Several weeks were spent in the Randsburg-Ridgecrest area and approximately 100 properties were visited. Several property descriptions based on field work were prepared.

Monterey County—Limestone deposits were examined. Economic possibilities of other commodities, including silica sand, were investigated. Geologic mapping (described elsewhere) was in progress.

Orange County—Several properties in Orange County were visited, and brief descriptions of them were prepared.

San Diego County—A summary of the mines and mineral deposits of the Julian area was completed, and numerous property descriptions of mines and deposits in the Jacumba, Carrizo Mountain, and Borrego areas were prepared. The field work has involved the preparation of geologic maps of the Julian area and of numerous mineral deposits. Several large areas in San Diego County, that would otherwise have been blank on the new state geologic map, were mapped on a regional basis. Also pursued in connection with the San Diego County work, was the Otay clay project and the inspection of several smaller clay deposits and operations.

Trinity County—Mining activities in the Altoona, Denny, Hayfork, and Mad River areas were checked in the field. Reports describing deposits of asbestos, chromite, coal, copper, and gold were prepared.

In addition to work on a county basis, a minerals inventory of the Joshua Tree National Monument was in progress. A study of the mines and mineral deposits of a large part of Joshua Tree National Monument was started. The completed report is to accompany a geological report on this area by John Rogers. Eleven properties were visited, and a written report was in progress at the end of the year.

County reports available in *California Journal of Mines and Geology* issues are listed below, except those out of print as noted.

Alameda	April 1950 [a]
Alpine	October 1931
Amador	January 1954
Butte	July 1949
Calaveras	July 1936 [a]
Colusa	July 1929
Contra Costa	October 1951 [a]
Del Norte	October 1952
El Dorado	October 1956
Fresno	July 1951
Glenn	January 1952 [b]
Humboldt	October 1941
Imperial	April 1942 [c]
Inyo	January 1951
Kern	April 1949 [a]
Kings	July 1953
Lake	January 1947
Lassen	October 1936
Los Angeles	July-Oct. 1954
Madera	October 1950
Marin	July 1955
Mariposa	January-Apr. 1957
Mendocino	October 1953
Merced	July 1952
Modoc	October 1936
Mono	April 1940
Monterey	January 1925 [a]
Napa	April 1948
Nevada	July 1941
Orange	January 1925 [a]
Placer	July 1927 [b]
Plumas	April 1937 [b]
Riverside	July 1945 [b]
Sacramento	April 1955
San Benito	January 1947
San Bernardino	January-Apr. 1953

San Diego	January 1939 [a]
San Francisco	April 1929 [b]
San Joaquin	January 1955
San Luis Obispo	October 1935 [b]
San Mateo	October 1955 [b]
Santa Barbara	October 1925 [b]
Santa Clara	April 1954 [b]
Santa Cruz	January 1943
Shasta	April 1939 [d]
Sierra	January 1942
Siskiyou	October 1947
Solano	April 1927
Sonoma	January 1950
Stanislaus	April 1947
Sutter	1920 [b]
Tehama	July 1946
Trinity	January 1941 [a]
Tulare	October 1930 [d]
Tuolumne	January 1949
Ventura	July-Oct. 1932 [b]
Yolo	July 1950
Yuba	April 1952 [b]

Out of Print:
[a] New report assigned and in progress.
[b] No assignment made.
[c] New report assigned but inactive.
[d] New report completed for early publication.

STATE GEOLOGIC MAP, 1:250,000

The Division of Mines is well advanced in the office preparation of a new geologic map which will cover the entire state of California. The scale, 1:250,000, or about 1 inch = 4 miles, is twice that of the previous state geologic map, prepared by Olaf P. Jenkins and published in 1938, scale 1:500,000, or about 1 inch = 8 miles. This older map has been out of print for 6 years. The base of the new map consists of the Army Map Service sheets, about 30 of which cover California and show topographic features by contour lines. Shaded relief shown on original sheets will not be shown on the geologic map. Each sheet is intended to cover an area of 2 degrees east-west and 1 degree north-south, but in some cases partial sheets will be combined with others. Geologic units will appear in various colors and patterns, about 90 in all. Although the sheets will be made available separately, or included in a loose-leaf atlas, they can also be trimmed and combined as regional wall maps. However, if the entire map were assembled for the wall it would cover an area of about 14 feet by 14 feet.

There is no project of the Division which serves useful purposes more universally than the state map. It requires continuous, intensive, and careful study; it is basic and needed in all mineral development, in scientific and engineering enterprises, such as road location, construction, water resources, agriculture, travel, and recreation. The geologic sheets will also be reprinted to show by other colors the distribution of economic minerals, and will indicate some of the relationships of geology to mineral deposits.

Preliminary work has begun on accumulating data for economic sheets, scale 1:250,000 to accompany the state geologic map. The economic sheets will have the same topographic base with geologic formational boundaries and symbols but the areal geology will not be shown in color. Salient features, including mineralized areas as well as the principal mines, will be shown in order to relate geology to the mineral commodities.

The preparation of this new map has now reached the point where some of the sheets are being processed for printing in full color during the next fiscal year. Eight sheets, covering part of southern California, have already been published but in a preliminary, uncolored edition, available for $1.00 each. These preliminary sheets have been received enthusiastically by both technical and lay public and many suggestions and new data have been received since their publication, which will be incorporated in the forthcoming colored geologic atlas.

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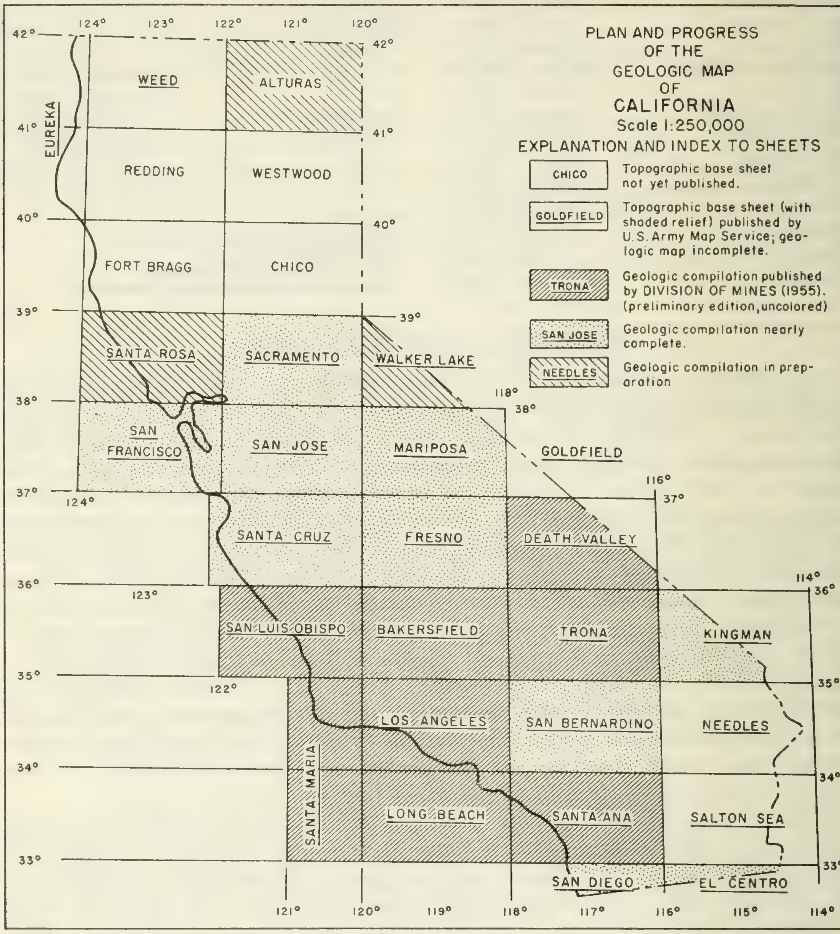

FIGURE 2. Map showing progress of the geologic map of California.

In conjunction with the preparation of the state geologic map, an index to all published areal geologic mapping in California has been compiled and is being kept up-to-date. It is intended that this useful guide will be published separately as a *Special Report*. The unpublished geologic maps used in compilation of the state geologic map have been systematically filed and indexed, so that all information used in preparation of the state map can be readily found by members of the staff.

Work has progressed on a master legend for the state geologic map to show how the various formational units are being grouped for units on the state maps. A card index of formational units is being kept up to date as work progresses and serves as a valuable source of information.

A *Glossary of Geologic Names of California*, which revises and brings up to date previous glossaries, is under preparation. It will contain

the names of all published formations, a brief statement of the basic geology and economic significance of each formation, and an accompanying bibliography of the publications wherein these formations were first formally described. The project is an evolving one, but the information is immediately available to staff and public in card-file form at headquarters office in San Francisco. A checklist of formational names will be the first published release of this project.

Results of recent reconnaissance geologic mapping of previously unmapped parts of the Sierra Nevada, eastern Mojave Desert, and northwestern California, have been made available to the project, and have helped to fill map areas previously left blank for lack of data.

It is also planned to issue a much smaller general geologic map, principally for school use. This map will also have an accompanying economic mineral over-print. It is intended that these maps will be published on the scale of 1 : 2,000,000. Both have been tentatively compiled, but await further revision as the larger state map is completed.

GEOLOGIC QUADRANGLE PROGRAM

The geologic mapping of quadrangles is done in part by staff members of the Division, in part by professors and graduate students affiliated with universities, in part by private research geologists or geologists who may be affiliated with geological departments of exploration companies, and in part by the U.S. Geological Survey through a cooperative program with the Division of Mines.

Quadrangle mapping projects actively under way by the Division staff include the San Fernando 15-minute quadrangle (prepared) by Gordon B. Oakeshott; Matterhorn Peak 15-minute quadrangle (field mapping completed, report in preparation) by Charles W. Chesterman; Shoshone 15-minute and south half of Tecopa 15-minute quadrangles (field mapping in progress) by Lauren A. Wright and Bennie W. Troxel; Hernandez Valley 15-minute quadrangle (nearly completed) by Charles W. Jennings; Monterey and El Portal 15-minute quadrangles (field work beginning) by Oliver E. Bowen, Jr.; Corona South 7½-minute quadrangle (map completed, report in preparation) by Cliffton H. Gray, Jr.; and Shadow Mountains 7½-minute quadrangle (field mapping in progress) by Bennie W. Troxel.

San Fernando quadrangle, in the western San Gabriel Mountains of Los Angeles County, has produced over $50,000,000 worth of petroleum, limestone, graphite, titanium ore, rock, sand, gravel, and volcanic ash. Matterhorn Peak quadrangle, in the high Sierra Nevada, is noted for its historic gold mines and tungsten potential. Shoshone-Tecopa quadrangles, in the southern Death Valley region, have deposits of lead, zinc, silver, gold, talc, saline minerals, pumice and perlite. Special attention was given to mapping the talc-bearing areas in the southwestern part of the Tecopa quadrangle and the southern part of the Shoshone quadrangle. Mapping also proceeded in the Virgin Spring Canyon area of the Confidence Hills quadrangle and in the Dublin Hills.

The field mapping for the Hernandez Valley quadrangle has been nearly completed and a composite office map has been compiled by transferring data from aerial photos and other field maps. The area

lies in the Diablo Range in San Benito and Monterey Counties. This quadrangle is of economic importance to petroleum exploration geologists because of the discovery of the Bitterwater oil field in 1952, and the Vallecitos oil field in 1955. Other mineral commodities produced in the past from this area are lignite, bentonite, magnesite, and asphalt.

Monterey quadrangle, on Monterey Bay, has yielded sand, diatomite, and dimension stone and is being explored for petroleum. El Portal quadrangle, west of Yosemite Valley, has produced barite, gold, silver, lead, zinc, limestone, dolomite, and slate. The Shadow Mountains quadrangle, in the Mojave Desert, is of greatest interest for the occurrence and mining of tungsten.

The Corona South quadrangle report, nearly completed, is particularly important because it describes newly discovered and newly developed clay deposits that are being worked on a large scale. This area also has the largest roofing granule operation in California, a recently opened rip-rap quarry, and the Corona glass sand quarry and plant which supply much of the glass sand consumed in southern California.

The following list shows progress of the basic geologic mapping program to July 1, 1957. *Only those quadrangles which the State Division of Mines has published or may publish are listed.* The quadrangles listed are 15-minute (scale 1 : 62,500), unless otherwise indicated. The letter preceding the name of the quadrangle indicates the affiliations of the geologists who are doing the work:

D—Division of Mines
U—University geologist
S—Federal Geological Survey (cooperative program)
O—Other professional geologist

The symbol (example, H-15) following the quadrangle name serves as a means of locating it on the accompanying index map.

Recently published geologic map and report:

S	Angels Camp 7½-min.	P-16
U	Antioch	K-16
D	Barstow 30-min.	C′-29, C′-30, D′-29, D′-30
S	Big Pine	Y-20
S	Bishop	Y-19
U	Blue Lake	C-5
O	Breckenridge Mt.	X-27
S	Calaveritas 7½-min.	P-16
U	Carquinez	J-16
S	Casa Diablo Mt.	X-18
S	Cuyamaca Peak	F′-37
U	Ferndale	A-16
U	Fortuna	B-6
O	Gaviota	R-31
U	Healdsburg	G-14
U	Jamesburg	L-23
U	Lebec 7½-min.	W-29
O	Lompoc	Q-30
O	Los Olivos	R-30
U	Lower Lake	H-13
U	Macdoel 30-min.	I-1, I-2, J-1, J-2
U	Mare Island	I-16
U	Mount Vaca	J-15
S	Mt. Goddard, NE⅓	X-20
S	Mt. Tom	X-19

S	Neenach	X-29
U	Ortigalita Peak	O-21
U	Petaluma	H-16
O	Point Arguello	P-30
O	Point Conception	Q-31
U	Point Reyes	G-16
U	Quien Sabe	N-21
O	Saltdale	A′-27
U	San Benito	N-22
U	San Jose, E½-Mt. Hamilton, W½	KL-19
U	San Juan Bautista	L-21
U	Santa Rosa	H-15
U	Sebastopol	G-15
U	Sonoma	I-15
S	Sonora 7½-min.	Q-17
U	Tesla	L-18
U	Vacaville	K-15

Geologic map only published:

U	Copperopolis	P-17
U	Hollister	M-21

Geologic map and report ready for press:

S	Darwin	B′-23
O	Lake Elsinore	C′-34
D	San Fernando	Y-31

Geologic map and report nearly ready for press:

U	Annette 7½-min.	R-27
U	Big Bend, SW¼	K-4
U	Campo	G′-38
U	Carbona	M-18
U	Colfax, S½	O-12
U	Cuyapaipe	G′-37
U	Dardanelles Cone	S-15
U	Desert Creek Peak	U-14
U	Helena	F-5
U	Morgan Valley, N½	I-13
U	Mt. Boardman	M-19
U	Orestimba	N-19
U	Oroville	L-10
U	Pleasanton	K-18
S	San Andreas, NW¼	O-16
U	Santa Ysabel	F′-36
U	Sonora Pass	T-15
U	Wilbur Springs, S½	I-12
U	Wheeler Peak	U-15

Geologic map completed, report in preparation:

D	Corona South 7½ min.	B′-33
U	Ebbetts Pass	S-14
O	Fremont Peak	C′-28
O & D	Hernandez Valley	O-23
D	Matterhorn Peak	U-16
S	New Almaden	K-20
S	New York Butte	A′-22
O	Opal Mt.	D′-28
U	St. Helena	I-14
S	San Andreas	P-16
S	Santa Catalina Island	X-35, Y-35
U	Sutter Creek	O-15
U	Topaz Lake	T-14

In preparation, field work completed or nearly complete:

U	Adelaida	O-26
U	Bradley	O-25
U	King City	N-24
D	Masonic Mt.	V-15
S	Mount Pinchot	Y-21
U	Nipomo	Q-28
U	Paso Robles	P-26

In preparation:

O	Auburn	N-13
D	Avawatz Pass, N½	G′-26
D	Bodie	V-16
U	Blairsden	P-9
U	Branch Mt.	R-28
U & D	Chilcoot	R-9
U	China Mt., S½	H-3
S	Devils Postpile	V-18
D	El Portal	S-18
U	Lucerne Valley, SW¼	E′-31
S	Mono Craters	V-17
D	Monterey	K-22
D	Mt. Abbot, S½	W-19
O	New Idria	P-23
U & D	Shadow Mts. 7½-min.	B′-30
D	Shoshone	G′-25
D	Tecopa, S½	H′-25
U	Valley Springs	O-16

NORTH COAST GEOLOGIC GUIDEBOOK

In 1952 the Division inaugurated a program of reconnaissance geologic mapping in previously unmapped areas of the Klamath Mountains. This is a region of rich mineral potential, about which there is very little basic geologic information. Geologic mapping of five quadrangles—Eureka, Trinidad, Orick, Klamath, and Crescent City—along the coast has been completed. On the basis of this mapping, a geologic guidebook to the coastal area between Eureka and the Oregon border is being prepared. It is the intention of the Division to continue the geologic guidebook work along the entire coast of California. It is a region of interest to the public, especially since many sections now are state parks, where maps and descriptions of the rocks are always much needed.

It was in the course of mapping the Crescent City quadrangle that nickeliferous laterite was discovered in Del Norte County. The mapping and study of these deposits has deferred completion of the guidebook.

BACKLOG OF COMPLETED UNPUBLISHED REPORTS

Besides the long list of quadrangle geologic maps and reports in progress, and projects underway by Division of Mines geologists, there are many contributions in the files of the Division waiting processing for publication. Titles of completed unpublished reports, ready for publication, when funds are available, are listed as follows:

Bishop, W. C., Geology of a part of the Santa Susana Mountains, California

Carman, M. F. Jr., Geology of the Lockwood Valley area, Ventura County, California. Ph.D. dissertation, Univ. California at Los Angeles, 194 pp. (revised manuscript received July 1957)

Chandra, D. K., Geology of the Colfax and Forest Hill quadrangles, California

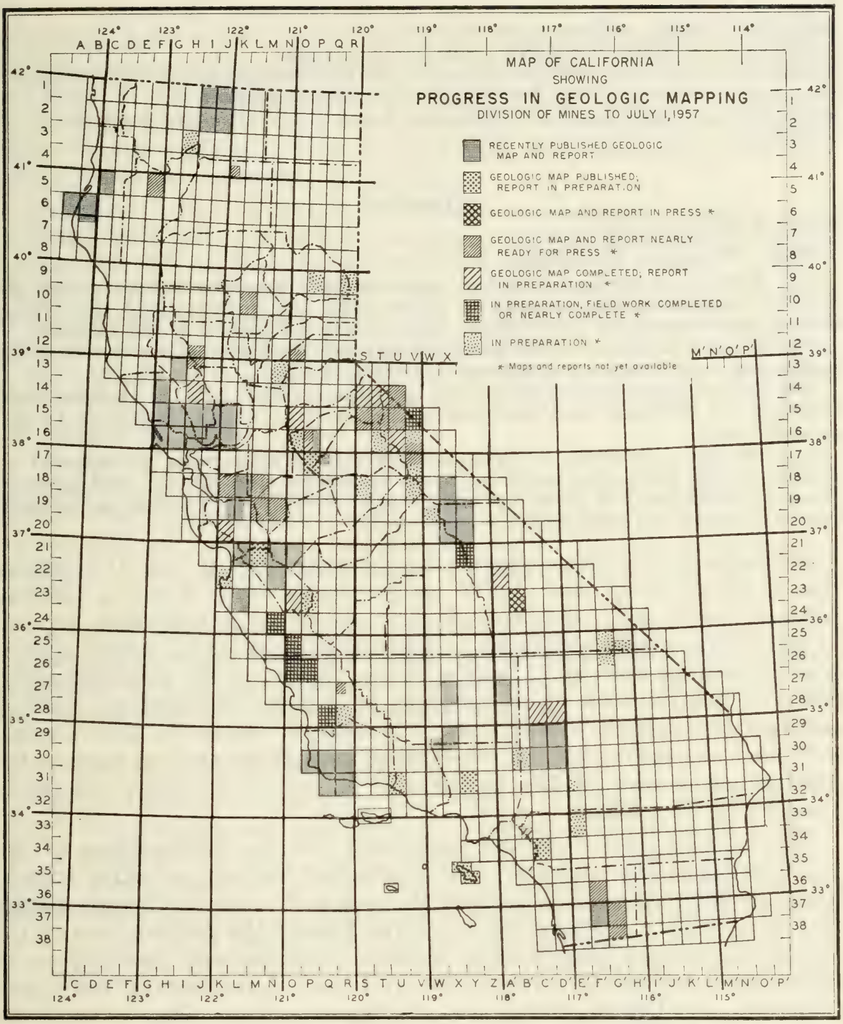

FIGURE 3. Map showing progress in geological mapping in California.

Cox, D. D., Geology of the Helena quadrangle, Trinity County, California
Dibblee, T. W. Jr., Geology of Caliente quadrangle, California
Hall, C. A., Brooks, S. A., and Jones, D. L., Geology of the Pescadero-Año Nuevo area, California
Herrera, L. J. Jr., Geology of the Tent Hills quadrangle, California
Marsh, O. T., Geology of the Orchard Peak area, California
McLaughlin, D. H., Geology of the Wartham Canyon area, California
Merriam, R., Geology of the Campo and Cuyapaipe quadrangles, California
Norris, R. M., Geology of San Nicolas Island, California
Pease, M. H. Jr., Geology of the Sobrante anticline, California
Pelletier, W. J., Geology of the Carbona quadrangle, California
Peryam, R. C., Geology of the Annette quadrangle, California
Plafker, G., Geology of SW Kaweah quadrangle, California
Richmond, J. F., Petrology and structure of the San Bernardino Mountains north of Big Bear Lake, California

Rogers, J. J. W., Geology of Joshua Tree National Monument, California
Ross, D. C., Geology of Sequoia Park area
Samsel, H. S., Geology of SE part Cross Mt. quadrangle
Sanborn, A. F., Geology and paleontology of the Big Bend quadrangle, California
Shuler, E. H., Geology of the San Timoteo badlands, California
Steuer, N. B., Tungsten deposits of the Mud Lakes district, Fresno County, California

LIBRARY

Public Resources Code:

"2205. The State Mineralogist shall: . . .

"(d) Provide a library of books, reports, and drawings bearing upon the mineral industries, the sciences of mineralogy and geology, and the arts of mining and metallurgy, such library constituting the library of the division.

"(e) Make a collection of models, drawings, and descriptions of the mechanical appliances used in mining and metallurgical processes.

"(f) Preserve and so maintain such collections and library as to make them available for reference and examination, and open to public inspection at reasonable hours.

"(g) Maintain, in effect, a bureau of information concerning the mineral industry of this State to consist of such collections and library, and arrange, classify, catalogue, and index the data therein contained, in a manner to make the information available to those desiring it."

Throughout the three-quarter century history of the Division of Mines, the Library has played an important role. From a shelf of donated books and pamphlets it has grown to a collection of over 21,000 volumes plus thousands of maps and other items, with a unique position among scientific libraries in the West for the comprehensiveness and compactness of its holdings in geology, mineralogy, mining, and related subjects. The Library is a research center for the technical staff and representatives of the mining industries, and, as part of the information service of the Division of Mines, its facilities are freely available to the public.

The Library is a complete depository for the publications of the U.S. Bureau of Mines and the U.S. Geological Survey, including unpublished geologic reports on California areas and mineral deposits placed on open file. The Library has extensive files of the publications of the geological surveys and mining bureaus, and learned institutions of other states and many foreign countries, and of the leading American, Canadian, and British mining and geological societies. The international scope of the collections has been developed for many years by a program of exchanges. During the past year exchanges were established with 17 institutions in this country and abroad including universities in Ontario, Wales, Spain, Japan, and Norway, and government departments in Mexico, Tasmania, and Morocco. A notable exchange acquisition was a file of more than 80 volumes of the Notes et Mémoires and geologic maps of the Geological Survey of Morocco.

The publications of the Division of Mines are distributed without charge to California libraries and schools, and a number of the larger public libraries and university libraries throughout the country. Some of them are also depositories with extensive files available for reference, to which inquirers in many areas may be directed. Much ot the Library correspondence is concerned with this program of distribution. During the year, 70 new libraries in California and elsewhere in the country were added to the mailing list. Many of the new California addresses

were high schools and district teachers professional libraries. Continuing the program of discussing the use of Division of Mines materials in the study of California resources, the librarian visited 50 schools and libraries in Humboldt, Trinity, Sutter, El Dorado, Amador, and Kern Counties and addressed meetings of school principals and supervisors, and a conference of county librarians.

Inquiries in the Library have indicated considerable interest among students and teachers in the vocational outlook and educational requirements for careers in mining and geology and related fields. In this connection a file of pamphlets issued by various firms and organizations has been assembled, as well as a collection of catalogues from most of the California universities and colleges and about 100 other North American institutions offering courses in geology and mining engineering. A selected reading list of 100 titles in geology and mining was prepared.

The use of materials in the Library continued at a high level. An increase was noted in the number of items used by staff members. Interlibrary loans increased to a total of 124 and there was a 25 percent increase in the number of publications distributed by stock order in addition to the regular distribution to the exchange and library addresses.

Important donations included 400 books and unbound government documents presented by Mr. Philip R. Bradley and a bound set of Industrial and Engineering Chemistry volumes 1-37, 1909-1945, from the Pacific Gas and Electric Company Library.

Miscellaneous Geologic Maps and Charts

Miscellaneous geologic maps and charts, largely published by the U.S. Geological Survey, are regularly received and added to the Division's Library collection. These include: geologic maps covering quadrangle areas, areas of oil and gas investigations, coal investigations, mineral investigations, geophysical investigations, and index maps for each state showing location of published geologic maps. During the last fiscal year the Division received and filed 278 maps of this category.

Books Added to Library During Fiscal Year 1956-57

Ahrens, Louis Herman. Quantitative spectrochemical analysis of silicates. Cambridge, Mass., Addison-Wesley, 1955.

American Association of Petroleum Geologists. Sample and core repositories of United States, Alaska, and Canada. Dallas, Core Laboratories, Inc., 1957.

American Geological Institute. Glossary of geology and related sciences. Washington, 1957.

American Geophysical Union. Antarctica in the International Year. A symposium. Washington, 1956.

American Institute of Mining and Metallurgical Engineers. Petroleum Branch. Secondary recovery symposium. Wichita Falls, Nov. 18-20, 1956.

American library annual for 1956-57. New York, Bowker, 1957.

American Petroleum Institute. Petroleum facts and figures. 12th ed. New York, 1956.

Amsden, Charles Avery. America's earliest man. 2d ed. Los Angeles, Southwest Museum, 1941.

André, Alexander. A Frenchman at the California Trinity River mines in 1849. New York, The Westerners New York Posse, 1957.

Anthony, Leo Mark. Elementary geochemical prospecting methods. University of Alaska. School of Mines, 1956.

Arkell, William Joscelyn. Jurassic geology of the world. New York, Hafner, 1956.

Association of College and Reference Libraries. A recommended list of basic periodicals in engineering and the engineering sciences. Chicago, 1953.

Association of College and Research Libraries. The administration of the government documents collection. Chicago, 1953.

Astle, Melvin Jensen. The chemistry of petrochemicals. New York, Reinhold, 1956.

Aubert de La Rue, Edgar. Man and the winds. New York, Philosophical Library, 1955.

Aukland, Merrill F. Clay mineralogy techniques; a review. Columbus, Ohio Division of Geological Survey, 1956.

Barnes, Hubert Lloyd. How to prospect for uranium. New York, Dover Publications, 1956.

Beaton, Kendall. Enterprise in oil; a history of Shell in the United States. New York, Appleton-Century-Crofts, 1957.

Berliner, J. J. Lightweight concrete. Compiled by J. J. Berliner & Staff. New York.

Bibliographic Index: a cumulative bibliography of bibliographies, 1951-1955. New York, Wilson, 1956.

Biffen, Frank Moody. Modern instruments in chemical analysis. New York, McGraw-Hill, 1956.

Birch, Robert W. Wyoming's mineral resources. Wyoming Natural Resource Board, 1955.

Blackett, P. M. S. Lectures on rock magnetism. Jerusalem, Weizman Science Press, 1956.

Bray, John Leighton. Ferrous process metallurgy. New York, Wiley, 1954.

Bretz, J. Harlen. Caves of Missouri. Rolla, Division of Geological Survey and Water Resources, 1956.

British Museum (Nat. Hist.) Dept. of Mineralogy. An index of mineral species and varieties arranged chemically. By Max H. Hey. 2d ed. London, 1955.

Brown, Charles Harvey. Scientific serials; characteristics and lists of most cited publications in mathematics, physics, chemistry, geology, physiology, botany, zoology, and entomology. Chicago, Association of College and Reference Libraries, 1956.

Browne, J. Ross. A tour through Arizona, 1864, or Adventures in the Apache country. Republished by Arizona Silhouettes. Tucson, 1951.

Buchsbaum, Ralph Morris. The life in the sea. Eugene, Oregon State System of Higher Education, 1954.

Cain, Ella M. The story of Bodie. San Francisco, Fearon Publishers in cooperation with Mother Lode Press, Sonora, Calif., 1956.

Calhoun, John C. Fundamentals of reservoir engineering. Rev. ed. Norman, University of Oklahoma Press, 1953.

California. Division of Highways. Materials manual of testing and control procedures. Sacramento, 1956.

California. Division of San Francisco Bay Toll Crossings. A preliminary report to the Department of Public Works on a San Francisco-Tiburon crossing of San Francisco Bay. San Francisco, 1957.

California. Division of San Francisco Bay Toll Crossings. A report to the Department of Public Works on the Southern Crossing of San Francisco Bay. San Francisco, 1956.

California. Division of Water Resources. Dams within the jurisdiction of the State of California. January 1, 1956.

California. University. Institute of Transportation and Traffic Engineering. Selected logs of borings in the City and County of San Francisco. Compiled jointly by the Institute and the U. S. Geological Survey. 1950.

California. University. Publications in Geological Sciences.

Smith, Hugh P. Foraminifera from the Wagonwheel formation. Devils Den district, California. Vol. 30, No. 2, 1956.

Axelrod, Daniel I. Mio-Pliocene floras from west-central Nevada. Vol. 33, 1956.

Campbell, Elizabeth Warder. An archeological survey of the Twentynine Palms region. Los Angeles, Southwest Museum, 1931.

Campbell, Elizabeth Warder. The Pinto basin site; an ancient aboriginal camping ground in the California desert. Los Angeles, Southwest Museum, 1935.

Carr, G. F. The granite industry of Canada. Ottawa, Department of Mines and Technical Surveys, 1955.

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TOPOGRAPHIC QUADRANGLE MAP FILE

Topographic maps form the basis for all geologic and mineral studies. They are invaluable to the staff of the Division as well as to the interested public.

The Division receives 16 copies of each newly completed U. S. Geological Survey topographic quadrangle map of areas in California that is published. The State Department of Water Resources provides the Division with 10 copies, while an additional 6 are sent directly from the U. S. Geological Survey. Advance prints of California quadrangles (subject to correction) are received from the U. S. Geological Survey for our inspection and comment before the final map is printed. The Division also receives from the Survey one copy of each new quadrangle map covering areas in the other western states.

One copy of each California quadrangle map is mounted on cloth and placed in the Library file for public inspection; other copies are distributed among the three branch offices and the remaining copies filed in reserve stock for field use by staff members. During the 1956-57 fiscal year the Division received newly completed topographic maps of 208 different quadrangles and advance sheets of 204 quadrangles covering different parts of California. During the same period, 823 out-of-state quadrangle maps were received. The total number of topographic maps received, including duplicates and re-orders, amounted to 4,761,

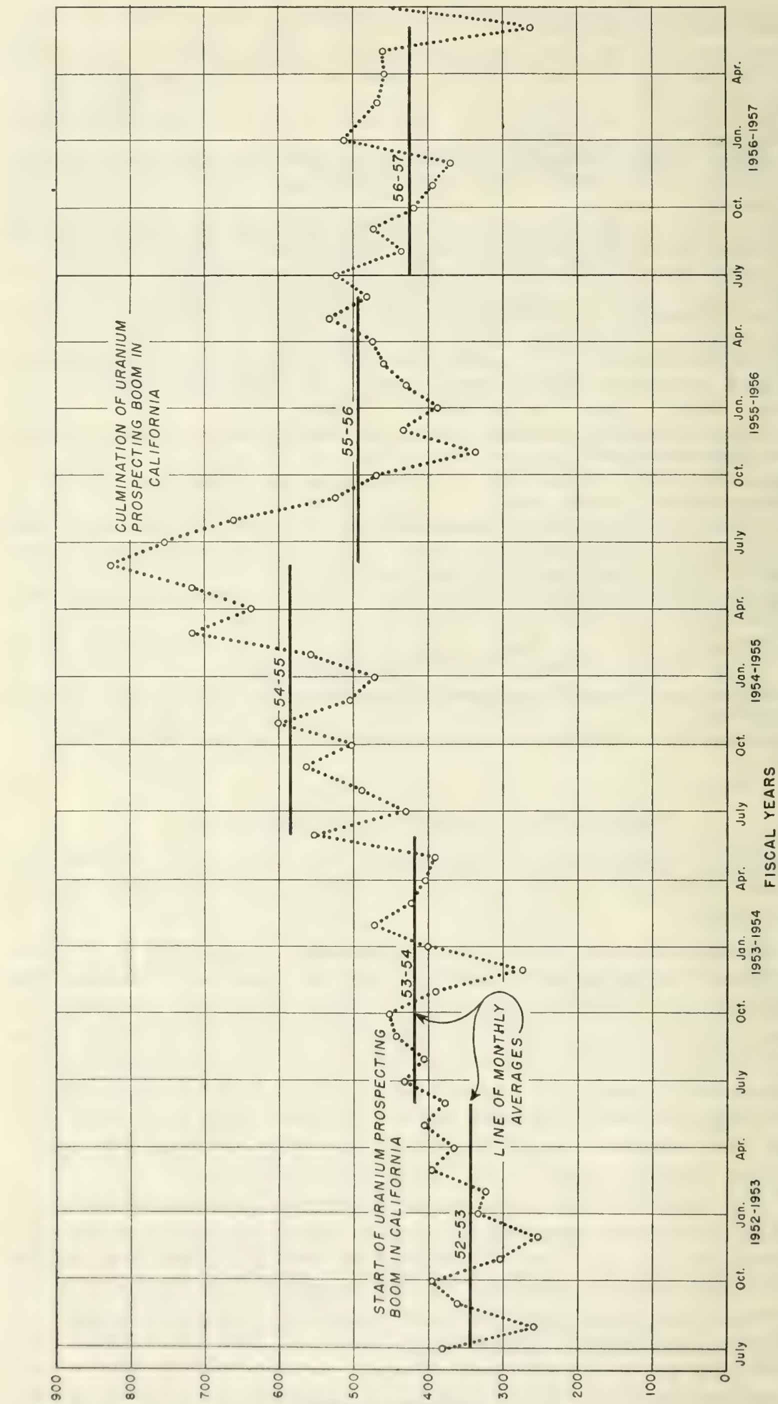

FIGURE 4. Graph showing mineral identification services of the Division of Mines.

The fine support the Division receives from both the U. S. Geological Survey and the State Department of Water Resources is much appreciated. The new topographic quadrangle maps made available to the public are announced in the Division's *Mineral Information Service.*

MINERAL LABORATORY

Public Resources Code:

"2202. The State Mineralogist shall maintain offices, and a laboratory in San Francisco for the purposes provided in this chapter."

During the 1956-57 fiscal year the public service laboratory of the Division of Mines received and reported upon 5,109 samples of ores, rocks, and minerals. This record indicates a continued interest in the development of California's mineral resources, in the program of the Division of Mines, and the satisfaction of the senders of the samples. Although the number represents a decrease of 14 percent below that of the previous fiscal year, 1955-56, it does not indicate any lack of care given to each request for analysis and the accuracy of the determinations. The decrease of service requested is directly due to the slackening off of interest in prospecting for radioactive materials.

The public service laboratory makes qualitative identifications, and only two samples per month are accepted from the sender since the present limited facilities and personnel are unable to handle any more than this number. Many different types of materials are received for identification, the majority of them consisting of various kinds of rocks (igneous, metamorphic and sedimentary) and the silicate-type of nonmetallic minerals. The demand for strategic ore minerals has not diminished and the search for them in the state has contributed much to the services demanded of the laboratories of the Division.

The research facilities of the Mineralogy and Petrology section, used only, but extensively, by the staff members, consist of the following: sieves and shaking machine for making screen analyses of silica sands, black sands, and dune sands; high temperature furnace to determine the expansion properties of shales and perlites, both useful as lightweight aggregates, and to determine the burning characteristics of ceramic white-ware materials; metallurgical polishing machine and microscope for studies of sulfide ore minerals; spectrograph used in qualitative and semi-quantitative spectrochemical analysis of materials; differential thermal analysis apparatus, used for basic studies of serpentines and associated garnierite, clay minerals, limestone, and expansible shale; petrographic microscopes and accessory equipment used in identifying rock and mineral samples and for making semiquantitative mineral analyses of rocks in thin section.

Mineral Discovery

During the course of a year many interesting and unusual minerals are received. The results of thorough investigations in our laboratory sometimes disclose that a mineral has been found which is the first reported occurrence from California; or a mineral may prove to be from a new location in the state.

The following minerals were identified in our laboratory during fiscal 1956-57 and reported upon for the first time in California:

Homilite ($Ca_2FeB_2Si_2O_{10}$), boro-silicate of calcium and iron.
Olivenite ($Cu_2(OH)AsO_4$), hydrous arsenate of copper.
Cyanotrichite ($Cu_4Al_2(OH)_{12}SO_4 . 2H_2O$), basic sulfate of copper and aluminum.

The following minerals were reported upon as coming from new localities in California:

Sanbornite ($BaSi_2O_5$), silicate of barium.
Adamite ($Zn_2(OH)AsO_4$), basic arsenate of zinc.

MINERAL EXHIBITS

Public Resources Code:

"2202. The State Mineralogist shall maintain offices, and a museum . . . in San Francisco for the purposes provided in this chapter."

"2205. The State Mineralogist shall: . . .

"(c) Make a collection of typical geological and mineralogical specimens, especially those of economic and commercial importance, such collection constituting the museum of the Division.

"(e) Make a collection of models, drawings, and descriptions of the chemical appliances used in mining and metallurgical processes."

"2206. The State Mineralogist may prepare a special collection of ores and minerals of California to be sent to or used at any world's fair or exposition in order to display the mineral wealth of the State."

During the fiscal year, 1956-57, reclassification of the mineral exhibit according to the Dana System was completed. This job brought to a close one of the most comprehensive examinations ever undertaken of this large mineral exhibit. Cataloging was started toward the close of the previous fiscal year, 1955-56, and by the end of fiscal 1956-57 the entire Dana collection and half of the exhibits in the county cases had been thoroughly checked and accurately cataloged.

The following table shows the distribution of the mineral specimens arranged according to several exhibit categories:

	Number of specimens
Dana collection	1973
Counties exhibits	1426
State exhibits	204
Foreign country exhibits	145
Metallic ore minerals exhibits	750
Non-metallic ore minerals exhibits	663
Building materials exhibits	305
Gem stone materials exhibits	237
Meteorite exhibit	14
Rock exhibits (igneous, sedimentary, and metamorphic)	353
Mineral fuels	122
Miscellaneous exhibits (including Crestmore minerals, fluorescent minerals, rock slices, quartz family minerals, uranium minerals, and gold gravels)	1051
Total specimens on exhibit	7343

The Mineral Exhibit continues to attract many people who are genuinely interested in rocks and minerals. School children often come in groups. During the fiscal year 1956-57, there were 30,468 visitors; of this total, 25,595 or 84 percent were adults, and 4,873 or 16 percent were school children.

All of the exhibits were available at all times the Division offices were open. The stamp mill and cement plant models, because of their moving parts, were especially attractive to the school children.

A total of 314 sets of typical California minerals and rocks (called "schoolite sets" by the Division of Mines) were provided on request

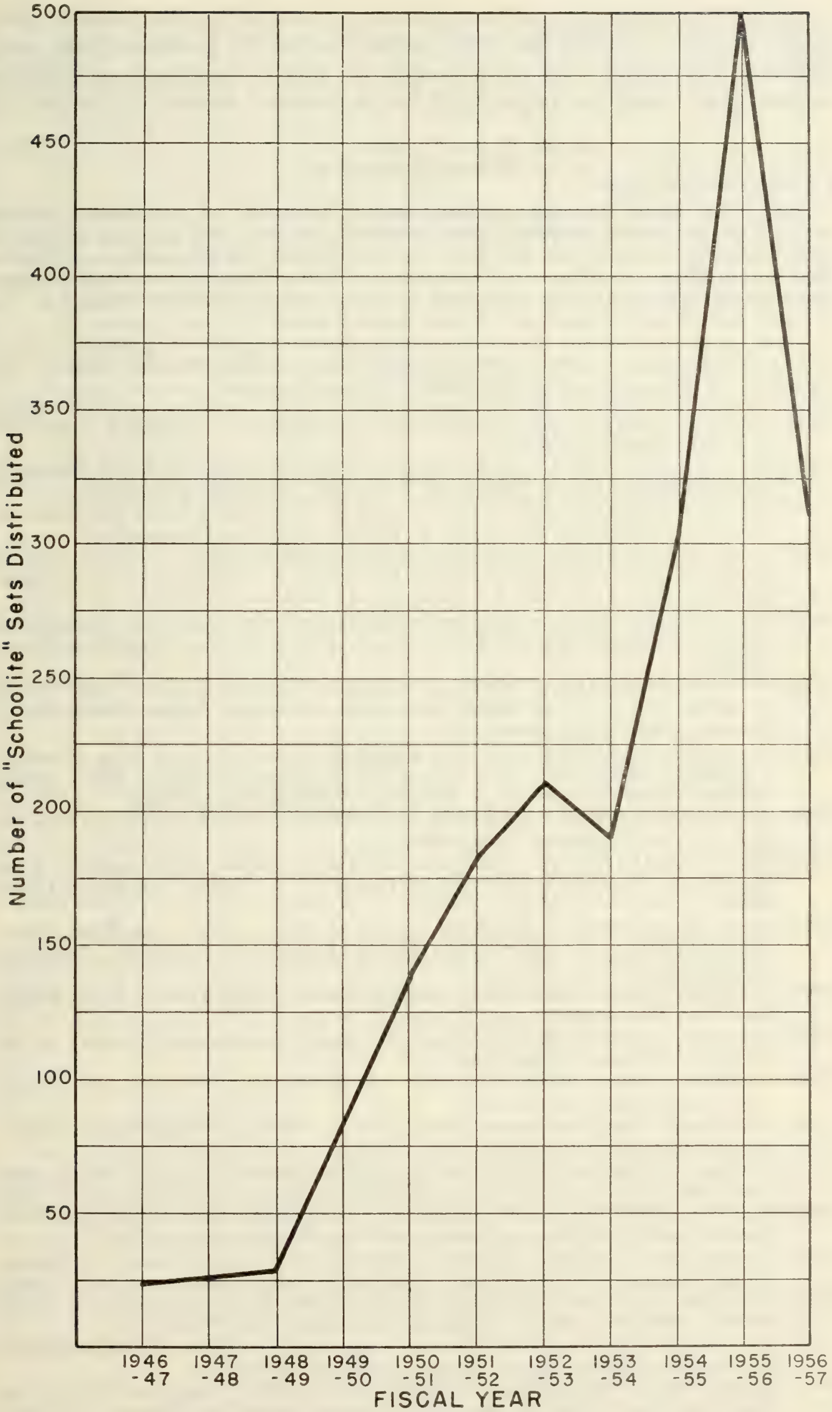

FIGURE 5. Graph showing distribution of "schoolite" sets.

to elementary schools in various places of California. The number provided represents a decrease of 37 percent below the previous fiscal year, 1955-56, indicating that distribution of this educational material is beginning to reach the majority of the elementary schools in California.

Mineral Accessions

Public Resources Code:

"2204. The State Mineralogist may receive on behalf of this State, for the use and benefit of the Division, gifts, bequests, devices, and legacies of real or other property and may use the same in accordance with the wishes of donors. If no instructions are given by the donors, the State Mineralogist shall manage, use, and dispose of the gifts, bequests, and legacies for the best interest of the Division and in such manner as he may deem proper."

The following specimens were donated to the Mineral Exhibit of the Division of Mines during the 1956-57 fiscal year.

21678 Scheelite ($CaWO_4$), calcium tungstate. Donor: Ben F. McDonald, Post Office Box 204, Hilmar, California.

21679 Beryl ($Be_3Al_2((SiO_3)_6)$, beryllium aluminum silicate. From Black Mountain, Oxford County, Maine. Donor: S. F. Feitler, Beryllium Corporation.

21680 Beryl ($Be_3Al_2(SiO_3)_6$), beryllium aluminum silicate with zoned black tourmaline. From Argentina. Donor: S. F. Feitler, Beryllium Corporation.

21681 Beryl ($Be_3Al_2(SiO_3)_6$), beryllium aluminum silicate. Four unusual types of beryl. From Minas Gerais, Brazil. Donor: S. F. Feitler, Beryllium Corporation.

21682 Beryl ($Be_3Al_2(SiO_3)_6$), beryllium aluminum silicate, with mica. From Black Mountain, Oxford County, Maine. Donor: S. F. Feitler, Beryllium Corporation.

21683 Beryl ($Be_3Al_2(SiO_3)_6$), beryllium aluminum silicate. Tapered beryl crystal (2 pieces glued). From Scotty Mine, Oxford County, Maine. Donor: S. F. Feitler, Beryllium Corporation.

21684 Beryl ($Be_3Al_2(SiO_3)_6$), beryllium aluminum silicate. Crystal from phosphate—uranium intermediate zone. From Scotty Mine, Plumbago Mtn., Oxford County, Maine. Donor: S. F. Feitler, Beryllium Corporation.

21685 Beryl ($Be_3Al_2(SiO_3)_6$), beryllium aluminum silicate. South Africa. Donor: S. F. Feitler, Beryllium Corporation.

21686 Beryl ($Be_3Al_2(SiO_3)_6$), beryllium aluminum silicate, with quartz. From Black Mtn., Oxford County, Maine. Donor: S. F. Feitler, Beryllium Corporation.

21687 Beryl ($Be_3Al_2(SiO_3)_6$), beryllium aluminum silicate, with mica. From Greenwood Township, Oxford County, Maine. Donor: S. F. Feitler, Beryllium Corporation.

21688 Beryllium (copper rod). From Reading, Pennsylvania. Donor: S. F. Feitler, Beryllium Corporation.

21689 Beryllium (copper chisel). From Reading, Pennsylvania. Donor: S. F. Feitler, Beryllium Corporation.

21690 Beryllium (copper spring and float). From Reading, Pennsylvania. Donor: S. F. Feitler, Beryllium Corp.

21691 Beryllium (Beryllium metal beads). From Reading, Pennsylvania. Donor: S. F. Feitler, Beryllium Corp.

21692 Colemanite ($Ca_2B_6O_{11} \cdot 5H_2O$) hydrous calcium borate. From Corkscrew mine, Corkscrew Canyon, Inyo County, California. Donor: J. Gill, April 14, 1957.

21693 Scheelite ($CaWO_4$), calcium tungstate. From Kings Canyon National Park, Fresno County, California. Donor: Arl Van Winkle, May 10, 1957.

21694 Banded Onyx ($CaCO_3$), calcium carbonate. From Colusa County, California. Donor: Eugene S. Prest, Route 1, Box 2533, Colfax, California, May 8, 1957.

21695 Cinnabar (HgS) mercuric sulfide. From Pancho Mine, Chileno Valley, Marin County, California. Donor: John D. Swearingen, Mill Valley.

21696 Pitchblende (UO_2) uranium dioxide. From Sec. 25, T13N, R10W, McKinley County, New Mexico. Donor: T. O. Evans, April 1957.

21697 Rutile (TiO_2), titanium oxide, contains 97% TiO_2. From Hanover County, Virginia. Donor: Carl R. Schroeder, Virginia Metal and Thermite Corporation, May 1957.

21698 Ilmenite ($FeTiO_3$), iron, titanium oxide. From Hanover County, Virginia. Donor: Carl R. Schroeder, Virginia Metal and Thermite Corporation, May 1957.

21699 Calcium larsenite ($(Pb,Ca)ZnSiO_4$), lead, calcium and zinc silicate. With franklinite, calcite and hardystonite. From Franklin Hill, New Jersey. Donor: Carl R. Schroeder, May 1957.

21700 Cinnabar (HgS), mercuric sulfide. Partially coated by liquid hydrocarbon. From Approx. 100 ft. from Harry shaft, Almaden Mine, Santa Clara County. Donor: John T. Whittaker, June 1957.

21701 Fergusonite ($Y(Nb,Ta)O_4$) yttrium, niobium, tantalum oxide. From: Sec. 1, T17S, R2E, SW slope of Lawson Peak, San Diego County. Donor: David S. Dewey, June 1957.

21702 Fergusonite ($Y(Nb,Ta)O_4$), yttrium, niobium, tantalum oxide. From: Sec. 1, T17S, R2E, SW slope of Lawson Peak, San Diego County. Donor: David S. Dewey, June 1957.

21703 Connellite ($Cu_{19}(SO_4)Cl(OH)_{32}\cdot 3H_2O$?) sulfate-chloride of copper. Only occurrence in California. From Buchanan Mine, Madera County. Donor: Ed Oyler, October 1956.

21704 Cyanotrichite ($Cu_4Al_2(SO_4)(OH)_{12}\cdot 2H_2O$), hydrated basic sulfate of copper and aluminum. From northwest of Clark Mountain, San Bernardino County, California. Donor: C. B. Hall.

21705 Scheelite ($CaWO_4$), calcium tungstate. Crystals from laumontite-phlogopite matrix. From Tyler Creek mine. Donor: National Tungsten Corporation.

MINERAL COMMODITY PROGRAM

In order to make available to the public a full coverage of the mineral potential of California, the Division has prepared for publication Bulletin 176, "*Mineral Commodities of California*—Geologic occurrence, economic development, and utilization of the state's mineral resources," which represents a complete revision of Bulletin 156, published in 1950. This report is the most complete commodity treatise yet undertaken by the Division and will undoubtedly be the most useful to the largest number of people. All members of the technical staff, including those of the Los Angeles, Sacramento, and Redding offices, as well as the main office at San Francisco, contributed to this undertaking. A detailed list of subjects treated in Bulletin 176 has been listed under the heading, "Publications of the Division of Mines," in this annual report.

In addition to this general review of Bulletin 176, special commodity studies of more extensive and detailed scope were continued. Each study requires statewide investigation and, therefore, staff members are obliged to extend their interests beyond areas immediately adjacent to their respective offices. Special commodity studies are reviewed as follows.

Limestone and Dolomite

Sampling and economic evaluation of limestone and dolomite deposits continued vigorously in 11 counties. A total of 100 samples was collected, sent out for analysis, and evaluated. Preliminary stratigraphic studies involving sampling were carried on in the late Paleozoic (?) rocks of the Coyote Mountains, Imperial County; the Paleozoic (?) Sur series of the Gabilan Range, Monterey and San Benito Counties; and the Sur series in the Pico Blanco vicinity of the northern Santa Lucia Mountains.

A paper on the economic possibilities of limestone and dolomite deposits in the northern Gabilan Range by O. E. Bowen and C. H. Gray neared completion at the end of the fiscal year. The first draft of a

paper on the geology and economic possibilities of the limestone and dolomite rocks of Standard quadrangle, Tuolumne County, by Earl W. Hart was reviewed and returned to the author for revisions. A paper on "Recent developments in limestones, dolomites and cement in California" by O. E. Bowen was transmitted for publication to Mining Congress Journal.

Several cement companies and one major steel company have been making extensive surveys of carbonate raw materials up and down the state and have drawn heavily on information in Division of Mines files.

Portland Cement

District-wide studies on cement raw materials were carried on near San Juan Bautista and in the San Diego marketing area. The Coyote Mountains of western Imperial County received special attention because of cement plant possibilities in that area.

Nearly all of the operating companies reported plant expansion and modernizations during the year. A new plant was placed in operation in April 1957 near Lucerne Valley, San Bernardino County, by Permanente Cement Company. Expansion by California Portland Cement Company of its Creal (Mojave) plant continued, ultimate capacity to be 3 times that of the plant completed in 1956. California now has three plants each capable of making over 6,000,000 barrels of cement annually. The Permanente plant near Los Altos, Santa Clara County, is the second largest in the world. Altogether there are 12 cement plants in California that manufacture clinker and a thirteenth plant processes clinker purchased from other companies.

For the first time since World War II cement production in southern California fell off from the previous year's production—the first indication that production may have caught up with or slightly exceeded demand. Northern California production continues to rise after a slight recession in 1956.

Micaceous Ceramic Materials

Preliminary testing was done on separation products made from crude sericite-pyrite ore from Plumas County. A clean white sericite was made by simple water separation methods. Fired at 1060° C. this material gave an off-white test disc of promising strength. Acid treated material fired much whiter. The deposit, reported to contain many millions of tons, may be of potential importance as a source of both pyrite for sulfuric acid and sericite for fillers and for possible ceramic uses.

Clay

Experiments concerned with firing tests to evaluate clays for brickmaking were performed, and samples submitted for this purpose were studied.

Experiments in determining the clay content of sedimentary rocks, by using chemical staining methods, reveal the possibility that staining methods can be modified for rapid analysis of samples in the field. In addition to locating new deposits, exploring for clay in this way may shed some light on the environmental significance of clay in oil-bearing sedimentary basins of California—a clue to oil accumulation itself.

During the year 1956-57 a detailed geologic map was made of the area that contains the principal exposures of the Otay bentonite deposit in southern San Diego County. In the 1930's this clay was worked as a commercial source of bentonite for use in oil well drilling muds and the deposit remains a potential source of this material.

Work was continued on the study of the alteration of volcanic rocks to clay in the Casa Diablo-Little Antelope Valley area of Mono County.

A regional map of the Alberhill clay-bearing area in Riverside County, and two detailed plane table maps of clay deposits in this area were edited and submitted as part of a report on the economic geology of the Elsinore quadrangle.

A commercial occurrence of fresh water diatomite in the Poverty Hills area of Inyo County was mapped and a report prepared for publication.

Silica

Substantial progress was made on the comprehensive survey of the silica resources of California that was begun last year. Field visits were made to 22 deposits, processing plants, and consuming plants.

Even though the survey is far from complete, the information already obtained is proving useful in helping potential consumers of silica to evaluate California's resources and to aid the owners of silica deposits with their marketing problems.

Sand

A suite of sand samples has been obtained from the desert area in central and eastern San Bernardino County, and a study of them was begun that should add to our knowledge of the desert sands and may indicate commercial uses for them. Screen analyses and size distribution diagrams of all samples have been made. Heavy liquid separations have been started preparatory to studying their heavy minerals.

Sand and Gravel

As a result of the new Federal Highways construction bill and closer cooperation between federal and state agencies (particularly the Division of Highways), the Division has received increasing numbers of inquiries as to the resources of sand and gravel and crushed stone in the state. To obtain this information, periodic field visits have been made by the Division and laboratory test data compiled. The studies of the major stream deposits, which furnish the bulk of the sand and gravel for concrete aggregate, are progressing steadily. The report on the aggregate resources of Cache Creek has been completed and is being edited for future publication. The field work on the resources of Putah Creek is 75 percent complete and field work on the Clear Lake area 25 percent complete. Included in these studies are geologic and petrographic discriptions of the deposits, results of laboratory tests and discussions of the economics of exploiting undeveloped areas. Many of the data are obtained from state and federal agencies who have made intensive investigations of construction materials for public works and who are cooperating with the Division in releasing unpublished reports containing valuable technical data.

The chemical behavior of rock used as aggregate in portland cement concrete has always been of concern to the sand and gravel producer. The Division has under preparation a report on the suspected chemical reactivity of the chalcedonic cherts of the Franciscan group. Chert, an important constituent of the gravels in streams which drain the Coast Ranges, has been considered by some concrete technicians to have deleterious effects in concrete. Preliminary data indicate that the rock type is not to be considered as a harmful ingredient.

Crushed Stone

The suitability of the geologic formations in the San Francisco Bay area for use as crushed rock, another important construction material, is being studied in detail in Contra Costa County as a part of the re-survey of the mineral resources of that county. Contra Costa County is unique in not having suitable deposits of sand and gravel and all construction materials must either be trucked or railed in, or quarried from suitable rock outcrops.

Dimension Stone

A statewide survey of the dimension stone industry, which was started to gather data for the Division's forthcoming Bulletin 176, was continued last year. The dimension stone industry while comparatively small has had significant increases in production principally because of the increased use of building stone in new homes and small industrial buildings. Information on the types and suitability of rock used, nature and extent of commercial deposits and economics of developing and marketing is being compiled through field visits and correspondence and is made available to the public by letter, personal conservation and by articles in the monthly *Mineral Information Service.*

Perlite

The Division of Mines has in preparation a report on perlite, which will include sections on geology of perlite, property descriptions, processing of perlite, and its utilization.

Obsidian

The Division of Mines has in preparation a report on obsidian, which will include geology of obsidian, descriptions of occurrences, and uses (ancient and modern).

Fluorspar

The Division of Mines has been making a statewide investigation of fluorspar deposits. Field studies of two properties were completed—Orocopia fluorspar, Orocopia Mountains, Riverside County; and Hope fluorspar, Bristol Mountains, San Bernardino County, California. Preliminary reports on these deposits are in preparation.

Nickeliferous Laterite Survey

During the year the Division of Mines survey of nickeliferous laterite deposits was summarized for the nickel sections of Bulletin 176. These deposits are the result of residual enrichment of nickel in laterite, a type of soil developed from serpentine bedrock by intense chemical

weathering. As far as is known they develop only under the influence of a tropical climate, such as prevailed in California during early Tertiary time. Reconniassance mapping and preliminary surface sampling have established that remnants of nickeliferous laterite are widely distributed in the Klamath Mountains and foothills of the Sierra Nevada, although the greatest commercial potential appears to be located in Del Norte County. On the basis of previous work by the Division and publication in *Mineral Information Service* of potential areas, several large mining companies have initiated exploration for nickel in California.

Jade

Statewide investigation of the jade occurrences was continued by the Division of Mines during 1956-57. Mapping of the geology of the Leech Lake area, northern Mendocino County, was completed and laboratory examination of the rock and mineral samples was started. The Leech Mountain area is of interest not only because of the jade that is mined there, but also from a scientific point of view. The intrusive contacts of the serpentine sills are particularly well exposed and careful study of their contact metamorphic zones and the host rock will aid greatly in solving some of the problems regarding the nature of the emplacement of serpentine bodies, the temperature and pressures of intrusion and the degree of metamorphism. Many commercial minerals are associated with the large bodies of serpentine that occur in California.

Borax

As part of a continuing program of keeping in touch with developments in the mineral industry, visits were made to the surface and underground facilities of the United States Borax and Chemical Corporation at Boron and to the adjacent mine of the California Borate Company, which is under development. The deposits at Boron account for an estimated 70 percent of the United States' borax production. Renewed interest in boron has been created both by the marketing of boron-bearing gasoline and press reports that the jet and rocket fuels of the future may contain boron compounds. The United States Borax and Chemical Corporation, in order to increase the quantity of borax available for these, as well as established uses, completed an open pit and a new refinery to replace its underground mines.

Peat

The first phase of a survey of California peat and coal was completed during the fiscal year 1956-57 and resulted in a systematic review of known California deposits. A summary report was submitted for publication in mineral commodities Bulletin 176.

A location map of all the known peat deposits in the state, prepared for this publication, shows that peat is widely distributed in California. At present, however, only four areas have been found that contain peat of suitable quality, quantity, and location to be of commercial value; nevertheless, the value of California's peat production is continually increasing and has nearly tripled in the past three years (from $73,897 in 1953 to $214,735 in 1956). This places California second in the

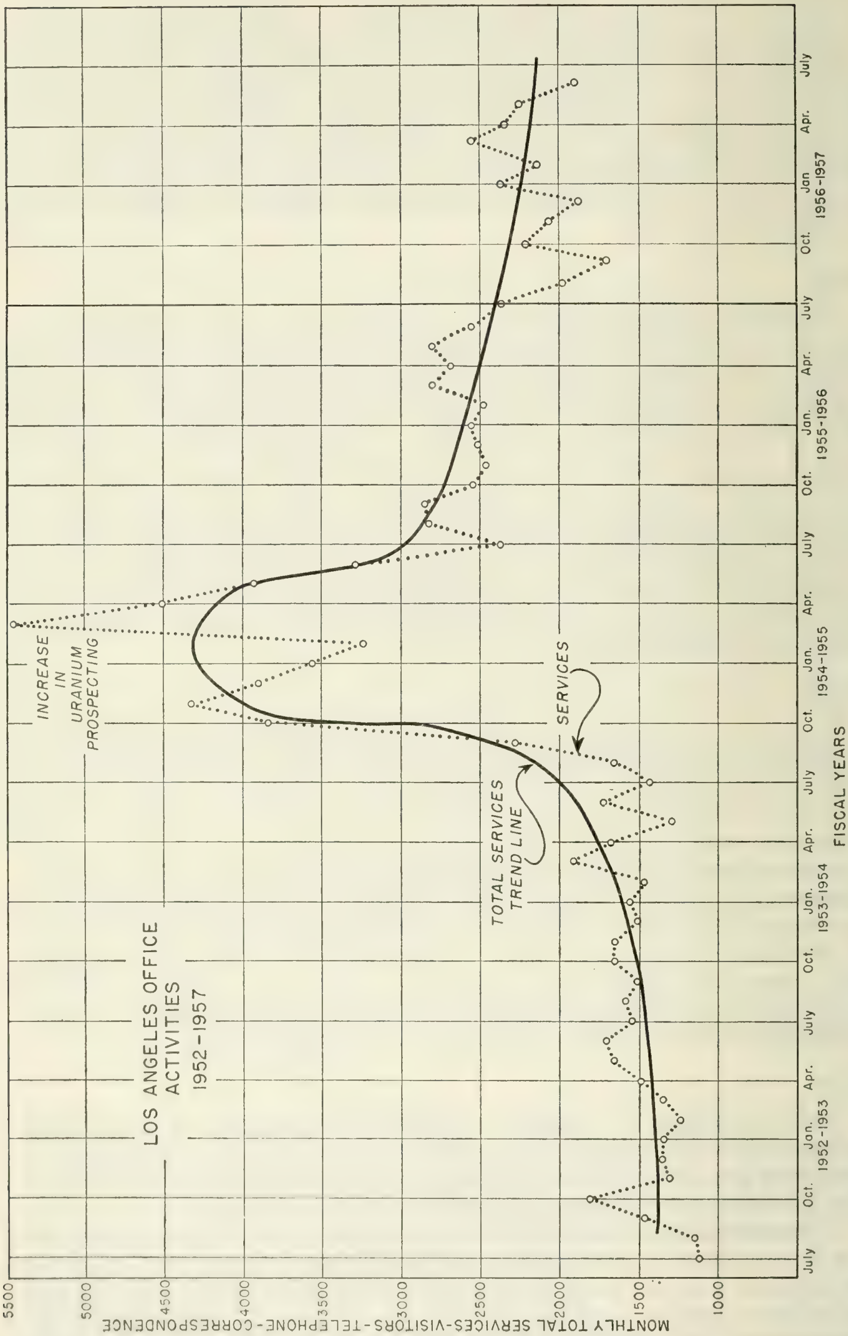

FIGURE 6. Graph showing activities of the Los Angeles Office, 1952-57.

United States for the value of peat produced in 1956. It is expected that further increases will occur as the demand for suitable soil conditioners continues to grow.

Coal

The greatest present value of coal deposits in the state is in the extractable montan wax which certain California lignites contain. Lignite from the Ione formation in Amador County has been found to yield a higher percentage of montan wax than other lignite in the United States. The extraction plant at Ione was recently expanded to keep up with the demand for this valuable high-melting-temperature industrial wax.

Oil and Gas

With California onshore oil and gas production declining, state-owned oil-potential land in offshore areas presents a promising and challenging future with possible rewards to the state in millions of dollars. The past year has been one of flux in California offshore operations while the state legislature replaced the Shell-Cunningham Tidelands Act with the Miller Bill (June 1957)—a bill that clears up leasing and royalty problems on state-owned tidelands. The public has been kept informed of these developments through *Mineral Information Service*. The forthcoming year should see a resumption of leasing and exploration of state-owned tidelands on a scale larger than ever before.

Biogeochemical Prospecting

A report on biogeochemical prospecting for molybdenum was processed for publication. The study showed significant anomalies, and suggested that one of the areas be sampled intensively. Since the report was written, one of the properties has been sampled, proving to contain a commercial body of molybdenum-bearing tungsten ore. It is a satisfaction to know of this success in the use of a new technique.

LOS ANGELES BRANCH OFFICE

During the fiscal year 1956-57 the Division of Mines members in the Los Angeles branch office were occupied mainly with completing their assignments for Bulletin 176, *Mineral Commodities of California*, the technical editing of which was done in Los Angeles, and in carrying on the county report program.

The public service activities in the Los Angeles office were at a slightly lower level than in the year 1955-56, but in most categories the services were considerably more numerous than during the period 1950 to 1954 which preceded the uranium rush. Publication sales were handicapped by the non-availability of many of our more popular items and by the fact that most of the publications issued during the year were of a technical or semi-technical nature.

In addition to Bulletin 176, the following projects were pursued during the year:

(1) Reports on Kern, San Diego, and Orange Counties.

(2) Detailed mapping of clay in the Casa Diablo area, Mono County, and in the Otay area of San Diego County; of diatomite in the Poverty Hills of Mono County; and of talc deposits in Inyo and San Bernardino Counties.

(3) The sampling of limestone deposits in San Bernardino and Los Angeles County; and assistance in the preparation of a report on the Gabilan limestone area in central California.
(4) Basic geologic mapping in the Corona quadrangle and southern Death Valley area.
(5) A review of reports contributed by geologists other than those of the Division of Mines staff.

The facilities of the Los Angeles office were improved by the addition of new furniture and equipment and by a modest expansion of the book and map libraries.

Office information services.

	1953-54	1954-55	1955-56	1956-57
Outgoing correspondence	3,526	4,467	3,225	3,016
Telephone calls	7,929	18,009	15,215	13,964
Visitors	7,540	19,004	13,187	11,343
Publication sales:				
Total pieces	7,001	12,924	7,628	5,506
Total value	$7,433	$17,104	$12,990	$6,221

SACRAMENTO BRANCH OFFICE

During the 1956-57 fiscal year there was a continuing demand for the services of the Sacramento branch office. The geographic location of this office makes it convenient for geologists, engineers, and prospectors interested in the mineral resources of the Sierra Nevada to come in for information and publications. There was a significant increase in the number of inquiries received from mining and manufacturing concerns regarding the mineral resources of this region, especially non-metallic minerals. Increasing population and industrial capacity in northern and central California with a resulting increase in the demand for raw materials make it imperative that more fundamental research be conducted into the nature of the mineral deposits of the area.

There was an over-all increase in office information services as compared with the previous fiscal year.

Office information services.

	1955-56	1956-57
Outgoing correspondence	1,706	1,650
Telephone calls	1,657	1,654
Visitors	1,882	2,065
Publication sales:		
Total pieces	1,075	1,216
Total value	$1,036	$1,204

During the past fiscal year, the technical staff, consisting of two mining geologists, worked on:

County reports—Calaveras and El Dorado
Mineral commodities—Gold, platinum, quartzite and quartz, sulfur and sulfuric acid, titanium.
Special projects—Alleghany-Downieville lode gold mines, Greenwood quadrangle, Mt. Abbot quadrangle, Poe Tunnel, Sierra Nevada and Great Valley activities survey.

Much time was devoted to the preparation of the Calaveras County report. A report on El Dorado County was completed and published in the *California Journal of Mines and Geology*. A report on the lode

gold mines at Alleghany and Downieville, completed in the previous fiscal year, was also published in the *California Journal of Mines and Geology*. An article on gold in California was published in the *Mineral Information Service*. Mineral commodity studies were made on gold, platinum, quartzite and quartz, sulfur, and titanium. A survey of the mining activities of the Sierra Nevada and portions of the Great Valley is continuously in progress and coordinated with other major projects and mineral commodity studies. In the past fiscal year a total of 135 mineral properties, including mineral-processing and manufacturing plants, were visited. A geologic section was made of the Poe Tunnel, Butte County; and a geologic map of the Greenwood quadrangle, Placer and El Dorado Counties, was begun.

REDDING BRANCH OFFICE

The Redding office continued to serve as an information center for the general public and for engineers and geologists in government service and private practice. Parents of children interested in rocks and minerals, scout leaders, and teachers visited this office to obtain lists of books and pamphlets on mineralogy and geology and to see the mineral collection. Prospectors brought in many samples for identification and obtained information on uses, current prices, and possible buyers of the commercial minerals they found. Questions relating to locating and patenting mining claims and suggestions on methods for developing prospects and concentrating ores were given when requested.

The office is served by one mining engineer whose work included checking mining activities in Del Norte, Humboldt, Shasta, Siskiyou, Tehama, and Trinity Counties. Arrangements have been made to add another technical employee to the Redding office during the following fiscal year.

Office information services.

	1954-55	1955-56	1956-57
Outgoing correspondence	1,185	1,192	479
Telephone calls	435	547	584
Visitors	1,428	1,075	1,105
Publication sales:			
Total pieces	370	308	396
Total value	$257	$271	$320

COOPERATION WITH OTHER STATE AGENCIES

At the request of the Director, Department of Natural Resources, an investigation was completed and a brief summary report was submitted on the mineral deposits within the boundaries of the Anza Desert-Borrego State Park. This report was needed to assist the Division of Beaches and Parks in their review of the boundaries of the Park with the intention of deleting, wherever possible, those areas that contained mineral deposits of some economic significance.

As work progresses on the Division of Beaches and Parks' Five Year Master Plan for development of the State Parks system, more Division of Mines' staff time will be involved in geologic and mineral deposits investigations. The preparation of layman's guides to assist the Park Naturalists and the evaluation of mineral potential in proposed park sites are some of the functions that the Division of Mines has been

requested to perform. Efforts to recognize this type of demand on Division of Mines' staff time by means of special budget planning were not successful.

In March 1957, while the Division of Beaches and Parks was engaged in negotiations pertinent to the acquisition of beach property at Palm Beach, Santa Cruz County, the Division of Mines was requested to prepare a report on the history of mining in the area and the nature and possible value of the mineral content of the beach sands. The Division of Mines then made the investigation, sampled the dune sands, examined the samples in the laboratory, and submitted a report to the Division of Beaches and Parks.

The Division also, at the request of the Director of Natural Resources, prepared a report summarizing the mining activities and mineral potential of the Eureka Bowl area, near Johnsville, Plumas County. All known mining properties were visited, and all available information was compiled to aid in determining the possible conflict of mining interests and recreational or other interests in the proposed Eureka Bowl State Park.

Cooperation between the Division of Mines and the Department of Water Resources continued, particularly in the exchange of geological data and the topographic quadrangle mapping program in California. Division geologists assisted the staff of the Department of Water Resources in the following ways: (1) classification of dry lake sediments in the Mojave Desert and part of the Basin-Ranges province; (2) correlation of the geology of the Poe Tunnel with tunnel-driving rates by preparing a map and cross-section; (3) providing information on the geology of the Morgan Valley quadrangle; (4) providing bibliographic data on the geology of the Feather River; (5) directing a staff geologist of the Department of Water Resources to potential sources of aggregate in the San Francisco Bay area along a proposed canal route.

Other state agencies also called upon the Division of Mines for assistance. The Division of Highways was helped in determining the value of a clay deposit in the path of a proposed freeway; the Division of Forestry requested a report—which was provided—on the geology and mineral resources of Mountain Home State Forest, in Tulare County; the Commissioner of the State Division of Corporations was provided with data on talc, clay, and uranium for use in state mineral lease areas; the Department of Employment conferred with the Division in regard to the outlook for employment in the mineral industries.

The Division of Mines also cooperated with the Geophysics section of the University of California at Los Angeles by supplying specimens of obsidian from Glass Mountain, Siskiyou County, from which Dr. Leon Knopoff constructed models for experimental measurements of the scattering of surface earthquake waves by topography.

The Division continued its long-standing cooperation with the California Academy of Sciences. The Division has been active in setting up and advising on the Academy's outstanding collection of California minerals.

REPORT OF THE U. S. GEOLOGICAL SURVEY ON COOPERATIVE STUDIES OF MINERAL DEPOSITS IN CALIFORNIA (FISCAL YEAR 1957)*

By Paul C. Bateman
U. S. Geological Survey
Menlo Park, California

Six projects were carried on by the U. S. Geological Survey during fiscal year 1957 under a cooperative agreement with the California State Division of Mines to study mineralized areas in California. These projects are: Sierra Foothills Mineral Belt, Panamint Butte Quadrangle, Eastern Sierra Tungsten, South Klamath Mountains, Mt. Pinchot, and Mt. Diablo. All except the Mt. Diablo project were cooperatively supported for the entire fiscal year; the Mt. Diablo project was not started until January 1, 1957, and was cooperatively supported for half a year. The cooperative program was of about the same magnitude as in the previous year and cost a little more than $70,000, of which $35,000 was borne by the State of California.

The Sierra Foothills Mineral Belt, Panamint Butte Quadrangle, and Eastern Sierra Tungsten projects were continued from the previous year, and the South Klamath Mountains, Mt. Pinchot, and Mt. Diablo projects were started this fiscal year. The South Klamath Mountains area adjoins the West Shasta Copper district, previously studied under the cooperative program, on the west, and is an extension of that study. Similarly, the Mt. Pinchot quadrangle adjoins the previously studied Bishop tungsten district on the south. The Mt. Diablo project is an outgrowth of quicksilver commodity work.

During the year five reports were published as a result of investigations carried out under the cooperative program. Two of these are Special Reports of the State Division of Mines, one is a U. S. Geological Survey Professional Paper, and two are U. S. Geological Survey Geologic Quadrangle Maps. In addition, two reports were approved for publication but have not yet been published, and four reports are being reviewed prior to approval for publication. Work was also continued intermittently during the year on the final report on the Trinity River project which was cooperatively supported last year, but which received no state support this year.

Sierra Foothills Mineral Belt

The region encompassed by the investigation of the Sierra Foothills mineral belt extends from about the latitude of Yosemite National Park on the south to the North Fork of the Feather River, near the north end of the Sierra Nevada. It is approximately bounded on the east by the Sierra Nevada batholith and on the west by the unconsolidated deposits of the Central Valley. Mineral deposits of the region have contributed greatly to the development of California, for the region includes the renowned Mother Lode gold belt and the Grass Valley and Alleghany gold districts. Copper mines of the western Sierra Nevada have also contributed significantly to the economy of the state, and recent exploration activity indicates continuing interest in these deposits. Increasing cement production emphasizes the importance of limestone deposits, which are relatively close to the rapidly expanding

* Publication authorized by the Director, U. S. Geological Survey.

industrial centers of the San Francisco Bay area and the Central Valley. Tungsten and chromite also have been mined from widely separated localities.

The western Sierra Nevada is underlain by metamorphosed sedimentary and volcanic rocks of Paleozoic and Mesozoic age, which are strongly folded and faulted. The strong deformation, together with a general scarcity of fossils, has hindered efforts to work out the stratigraphy and structure of the metamorphic rocks, although geologic maps of the region, mostly published between 1895 and 1900, do show the general distribution of the rocks. The present investigation utilized the methods of physical stratigraphy in detailed mapping of geologic cross sections in river canyons that cross the geologic structure at intervals along the metamorphic belt. Data obtained from study of the canyon sections are used to supplement the earlier geologic maps to arrive at an understanding of the geologic history of the region and knowledge of the setting of its ore deposits.

Most of this fiscal year was occupied by laboratory work and the preparation of reports, although a few weeks were spent in field checking previously studied areas and in reconnaissance study of major fault zones north of the part of the region that has been studied in detail. A report on the stratigraphy and structure of the part of the region that lies south of Plymouth is in preparation for publication by the U. S. Geological Survey. Preparation of another paper describing the relation of copper and gold deposits to host rocks and major structures was begun.

Panamint Butte Project

The Panamint Butte project is part of a long range program to study the lead-silver-zinc deposits of Inyo County, California. The Panamint Butte quadrangle adjoins the Darwin quadrangle on the east and is the fourth quadrangle in this region to be mapped under the cooperative program. It contains the northern part of the Modoc lead-silver district and several smaller mines in the Panamint Range. During the year the project was enlarged to include the northwestern part of the adjoining Maturango Peak quadrangle which contains the rest of the Modoc district. The Defense, Modoc, and Minnietta mines are within the area added.

Mapping was started during the last month of fiscal year 1955 and is about 85 percent completed. The quadrangle is structurally complex, and a major phase of the work is to unravel the history of faulting and of the extensive brecciation of Paleozoic rocks along the crest of the Panamint Range.

Two reports now under preparation will result from the investigation: one emphasizes the economic geology of the Modoc district, and the other is a description of the structure and stratigraphy of the quadrangle.

Eastern Sierra Tungsten

The Eastern Sierra tungsten project area includes five 15-minute quadrangles north and west of the Bishop tungsten district. Within it are deposits of tungsten, molybdenum, gold, silver, copper, lead, zinc, iron, kaolinite clay, perlite, pumice, and sand and gravel. The area is being mapped on a quadrangle basis, and reports are being prepared

for each quadrangle as the mapping is completed. Mapping of two quadrangles, the Casa Diablo Mountain and Mt. Morrison quadrangles, has been completed and mapping is in progress on the Devils Postpile quadrangle. Two reports dealing with the Casa Diablo Mountain quadrangle were published in the spring of 1957. One, on the economic geology, was published by the California State Division of Mines as Special Report 48, and the other, on the general geology, was published by the U. S. Geological Survey as Geologic Quadrangle Map GQ 99.

A report on the geology and mineral deposits of the Mt. Morrison quadrangle was revised and resubmitted for further review. Included in the report are descriptions of the metallic and nonmetallic mineral deposits and a comprehensive discussion of the general geology with particular emphasis on the stratigraphy of a roof pendant that contains locally fossiliferous metamorphic rocks, that range in age from Early Ordovician to Jurassic (?). The Paleozoic section consists of weakly metamorphosed fine-grained sedimentary rocks that are more than 30,000 feet in total thickness. The Jurassic(?) section is more than 17,000 feet thick and consists of weakly metamorphosed volcanic tuffs, flows, hypabyssal intrusives, and a small amount of tuffaceous metasedimentary rocks.

Field mapping was begun in the Devils Postpile quadrangle and about 40 square miles were mapped during a field season of 3½ months. Most of the mapping was done in a roof pendant, composed chiefly of metavolcanic rocks, which is more than 10 miles wide measured perpendicular to the strike of the beds. The metasedimentary and metavolcanic rocks lie along the projected strike of similar rocks in the Mt. Morrison quadrangle, but are areally separated from them by volcanic and plutonic rocks.

Mt. Pinchot Quadrangle

The Mt. Pinchot quadrangle adjoins the Bishop tungsten district on the south and contains small deposits of tungsten and gold. It covers part of the steep eastern face of the Sierra Nevada, the crest and the upper part of the western slope, and is one of the most rugged quadrangles in the state. At the end of the 1956 field season the quadrangle was more than half mapped and mapping will be completed during 1957. A report will be submitted by July 1958.

The quadrangle consists largely of granitic rocks, which enclose bodies of metamorphosed sedimentary and volcanic rocks. The granitic rocks include several intrusive masses of somewhat different appearance and composition, which are in sharp contact with one another or are separated by thin septa of metamorphic rock or diorite. The metamorphic rocks belong to two series, one of metasedimentary rocks of chiefly Paleozoic age on the east, and one of metavolcanic rocks of Mesozoic age on the west. Both series continue to the north and south beyond the quadrangle boundaries.

The ore deposits are related to the metamorphic rocks. The tungsten deposits are of contact metamorphic origin, and are generally confined to contacts between granitic rocks and marble.

South Klamath Mountains

The South Klamath Mountains project was started in fiscal year 1957. It has as its objective the geologic mapping and appraisal of the

mineral resources of a tier of 15-minute quadrangles across the southern Klamath Mountains starting from the west side of the West Shasta copper-zinc district. The area to be mapped is relatively unknown geologically, but is the center of intense mineral prospecting activity at present. Several major mining companies started exploration programs for copper in the area during 1956-1957, and the U. S. Bureau of Reclamation is conducting surveys and diamond drilling in preparation for construction of two dams and tunnels that are a link in their Trinity River project.

The west half of the French Gulch quadrangle was mapped during fiscal year 1957. The eastern half of the quadrangle was mapped previously as part of the cooperative West Shasta copper-zinc project, and was published this year in U. S. Geological Survey Professional Paper 285, ''Geology and base-metal deposits of the West Shasta copper-zinc district, Shasta County, California.'' Recognition of a thrust fault and several large strike-slip faults, which seem to be one of the ore controls for copper mineralization, resulted from the new mapping.

Mount Diablo Project

The Mount Diablo project, which began January 1, 1957, is an outgrowth of work done under the U. S. Geological Survey's quicksilver commodity study and the Defense Minerals Exploration Administration program in the Mount Diablo quicksilver district. The area mapped covers about 25 square miles in adjoining parts of four $7\frac{1}{2}$-minute quadrangles. Within this area asbestos, copper, gold, quicksilver, silver, and rock aggregate have been mined.

Mount Diablo is along the eastern edge of the central Coast Ranges and presents one of the easternmost exposures of Franciscan rocks in the state. The area studied, roughly circular in plan, includes most of fault-bounded Mount Diablo. The mountain is underlain by Franciscan rocks and diabase separated by a band of serpentine. Copper, gold, and silver deposits are limited to the diabase area; asbestos to the serpentine bodies; and quicksilver to the Franciscan rocks and altered serpentine. Mine mapping and study of old mine maps of the Mount Diablo district shows that the boundary fault is the principal structural control of ore and that the downward continuation of this structure may contain additional ore shoots.

A report dealing with the geology and mineral deposits of this area is being prepared.

Trinity River Basin Project

Field work on the Trinity River Basin project was completed during fiscal year 1956, and this investigation was not continued as a cooperative project this year. However, laboratory and office work was continued part time during the year, and the final report tentatively entitled ''Geologic reconnaissance of the northern Coast Ranges and Klamath Mountains, California'' was nearly completed.

A study was made of the K-feldspar content of the Jurassic and Cretaceous graywackes of the northern Coast Ranges and Sacramento Valley. The results show that the K-feldspar content can be used to help differentiate the several belts of graywacke.

CALIFORNIA MINERAL COMMODITIES IN 1955 AND 1954 †

By Henry H. Symons * and Fenelon F. Davis **

OUTLINE OF REPORT

Illustrations

PRODUCTION OF MINERALS IN CALIFORNIA DURING 1955 AND 1954

The value of mineral production in California during 1955 increased nearly 2 percent over the value recorded during 1954. The figures were $1,458,729,633 and $1,431,103,193 respectively. The value for 1955 was a new all-time high for the fifth consecutive year according to tabulations compiled by the U. S. Bureau of Mines in cooperation with the California Division of Mines. The value of mineral production in the state during 1955 exceeded the billion-dollar mark for the eighth consecutive year.

Since 1902 petroleum has been the most valuable mineral commodity in the state. During 1955 it was followed in value by natural gas, cement, natural gasoline, sand and gravel, stone, borates, liquefied petroleum gases, tungsten concentrates, iron ore, diatomite, sodium salts, gold, salt, potassium salts, sulfur products, clay, lime, magnesium compounds, gypsum, mercury, and lead.

Natural gas was the only major member of the fuel group to record an increase in both quantity and value during 1955. The value of natural gas was the highest on record although the quantity of production was well below the all-time high recorded in 1948.

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Structural mineral materials which registered new all-time highs in both quantity and value during 1955 included cement and gypsum. Sand and gravel reached its high point during the previous year and dropped off slightly in 1955. Diatomite production forged ahead to new high levels. In the saline group, new all-time highs were registered by borates, salt, sodium salts and potassium salts during 1955.

Tungsten concentrates and iron ore touched new high points of production and value in the metal group in 1955. The production of gold, lead, and zinc increased during 1955, but chromite, mercury, and manganese ore production dropped compared to 1954.

The value of mineral production in 1954 ($1,431,103,193) was an increase of 2 percent over 1953. The principal commodities produced were: petroleum, natural gas, cement, natural gasoline, sand and gravel, stone, borates, liquefied petroleum gases, tungsten concentrates, iron ore, sodium salts, gold, diatomite, and salt.

California mineral production in 1955.

Mineral commodity		Quantity	Value
Boron minerals	short tons	924,496	$33,816,464
Cement	barrels	35,084,415	103,793,702
Chromite ore and concentrates	short tons	22,105	1,834,277
Clay (raw)*	short tons	2,101,464	4,223,068
Copper	short tons	613	457,298
Gold	fine ounces	251,737	8,810,795
Gypsum	short tons	1,307,625	3,273,724
Iron ore	long tons	1,776,536	**
Lead	short tons	8,265	2,462,970
Lime	short tons	268,009	4,372,789
Magnesium compounds	short tons	58,839	3,894,432
Manganese ore and concentrates over 35% Mn	long tons	6,589	563,156
Manganese ore and concentrates under 35% Mn	long tons	16,424	638,651
Mercury	flasks	9,875	2,867,206
Natural gas	M cubic feet	538,178,000	119,475,516
Natural gas liquids			
Natural gasoline	barrels	22,134,500	89,003,000
Liquefied petroleum gases	barrels	8,592,900	19,379,000
Perlite (crude)	short tons	15,653	125,113
Petroleum	barrels	354,737,000	886,820,000
Pumice, pumicite, volcanic cinders	short tons	797,306	1,099,459
Salt	short tons	1,314,835	6,751,420
Sand and gravel	short tons	64,878,648	66,820,360
Silver	fine ounces	954,181	863,582
Stone (miscellaneous)***	short tons	13,730,769	20,732,950
Sulfur ore	long tons	199,599	**
Strontium minerals	short tons	177	4,425
Talc, soapstone, pyrophyllite	short tons	166,551	1,552,783
Tungsten concentrates (60% WO_3)	short tons	4,383	16,200,924
Zinc	short tons	6,836	1,681,656
Total apportioned			$1,401,518,720
Unapportioned**			57,210,913
Total value for 1955			$1,458,729,633

* The total value of clay was $5,027,381; from this deduct the value of clay sold or used in cement (758,931 tons), $804,313, leaving the balance of $4,223,068.

** Includes asbestos, barite, bromine, calcium chloride, carbon dioxide, coal (lignite), diatomite, feldspar, fluorite, garnet, gemstones, iodine, iron ore, lithium compounds, magnesite, marl, mica, molybdenum concentrates, peat, platinum group metals, potassium salts, pyrites, rare earth concentrates, slate, sodium salts, sulfur ore, by-product sulfur, titanium concentrates.

*** Total value, stone, was $37,164,384 from this deduct the amount of limestone used in lime (514,818 tons), $917,095, and in cement (10,462,734 tons), $15,514,339, leaving the balance of $20,732,950.

Value of total recorded production in California by substances to and including 1955.

Mineral products in order of total value	Year of first recorded production	Total value to 1955[a] inclusive	Value of 1955[a] output	Peak value in	Peak output in	Major producing counties in order of value of mineral output in 1955	Remarks
Petroleum	1865	$14,524,356,076	$886,820,000	1953	1953	Los Angeles, Kern, Ventura, Orange	California's output is exceeded only by that of Texas. Total value of the petroleum output is larger than the total of all other minerals produced in California.
Gold	1848	2,372,214,851	8,810,795	1852	1852	Yuba, Sacramento, Nevada, Sierra	California led U. S. in gold output until 1941, now ranks third.
Natural gas	1888	1,326,217,314	119,476,000	1955	1948	Los Angeles, Kern, Ventura, Sacramento	California ranks second in output among the states.
Cement	1891	1,306,624,475	103,793,702	1955	1955	San Bernardino, Santa Clara, Riverside	California ranks second in output among the states.
Miscellaneous stone	1893	1,012,743,471	87,553,310	1954	1954	Los Angeles, Alameda, San Diego, San Bernardino	California leads U. S. in ouput of sand and gravel; ranks high among the states in production of crushed stone. Does not include limestone used for cement or lime.
Natural gas liquids	----	791,232,000	108,382,000	1954	1954	Los Angeles, Kern, Ventura, Orange	California ranks second in output among the states. Until 1947 the value was not included in the total.
Borates	1864	309,996,714	33,816,464	1955	1955	Kern, San Bernardino, Inyo	Chief source of world's supply.
Copper	1882	200,696,540	457,298	1916	1909	Inyo, Amador, El Dorado, San Bernardino	Shasta County led from 1897-1918. Plumas from 1919-40. Siskiyou from 1941-44.
Brick and hollow building tile	1893	175,032,616	----	1923	----	----	Not canvassed by U. S. Bureau of Mines. Until 1947 was tabulated as a mineral product.
Mercury (quicksilver)	1850	159,090,982	2,867,206	1943	1877	San Benito, Sonoma, Lake, San Mateo	California leads U. S. with approximately 52% of total output.
Soda (soda ash and salt cake)	1894	136,687,374	[b]	1955	1951	San Bernardino, Inyo	California leads U. S. in the production of natural sodium carbonates and sulfates.
Potash	1914	128,260,231	[b]	1953	1950	San Bernardino, Santa Cruz	California ranks second in U. S. 1948 value not included in total.
Tungsten ore	1905	114,217,610	16,200,924	1955	1955	Inyo, Mono, San Bernardino, Madera	California ranks second in output among the states.
Diatomite	1889	91,717,314	[b]	1955	1955	Santa Barbara, Los Angeles, Napa	California is chief source of U. S. supply.
Salt	1887	89,746,132	6,751,420	1955	1955	Alameda, San Bernardino, San Diego	California ranks high among the states.
Silver	1880	80,836,763	863,582	1921	1921	Inyo, Siskiyou, Kern, Nevada	California's output comes from ores of other metals.

Value of total recorded production in California by substances to and including 1955—continued.

Mineral products in order of total value	Year of first recorded production	Total value to 1955[a] inclusive	Value of 1955[a] output	Peak value in	Peak output in	Major producing counties in order of value of mineral output in 1955	Remarks
Iron ore	1881	69,495,523	b	1955	1955	Riverside, San Bernardino	With the construction of the Fontana steel mill in 1942, production has shown a steady increase.
Clay (raw)	1887	56,332,953	4,222,068	1955	1955	Los Angeles, Riverside, Amador, Kern	California ranks high among the states. Includes bentonite since 1947 but does not include clay used in cement.
Lime	1894	54,727,297	4,372,789	1953	1953	Monterey, El Dorado, Tuolumne, San Bernardino	Lime was included with limestone 1941-46.
Lead	1877	46,192,112	2,462,970	1951	1950	Inyo, El Dorado, San Bernardino	Darwin district is the principal producing area.
Mineral water	1887	c40,601,881	----	1929	1946	----	Represents that which was bottled for sale. Figures not compiled by U. S. Bureau of Mines.
Magnesium compounds (recovered from sea water)	1916	40,349,078	3,894,432	1955	1955	Alameda, Monterey, San Mateo	California ranks second in output among the states.
Gypsum	1887	35,559,491	3,273,724	1955	1955	Imperial, Riverside, Kern, San Luis Obispo	California ranks second in quantity among the states.
Zinc	1906	32,819,158	1,681,656	1951	1926	Inyo, San Bernardino, El Dorado	California output is by-product of lead and copper mining.
Granite (dimension stone)	1887	c29,585,027	d	1925	----	San Diego, Placer, Tulare, Madera	Total included with miscellaneous stone since 1947.
Limestone	1894	c26,075,905	d	1946	1946	El Dorado, Tuolumne, San Bernardino	Does not include that used in cement or lime.
Talc, pyrophyllite, soapstone	1893	25,571,463	1,552,783	1952	1955	Inyo, San Bernardino, Mono, El Dorado	California ranks first in output among the states.
Coal	1861	23,678,284	b	1880	1880	Amador	Lignite in Amador County is mined for montan wax content. California is chief source of montan wax in U. S.
Pyrite	1898	22,216,812	b	1909	1909	Shasta	California ranks third in output among the states.
Chromite	1869	20,921,707	1,834,277	1918	1918	San Luis Obispo, Fresno, Del Norte, Siskiyou	California leads the nation in output.
Magnesite	1887	19,373,894	b	1917	1917	Santa Clara	Production of the natural mineral is being replaced by use of magnesia from sea water.
Iodine	1929	18,030,678	b	1952	1952	Los Angeles, Orange	California is only producing state in the U. S.
Pumice, pumicite and volcanic cinders	1909	12,006,610	1,099,459	1951	1955	Inyo, Siskiyou, Mono, Lassen	California is second among the states. Volcanic cinders included since 1953.

Silica (quartz and sand)	1899	11,588,501	d	1946	1946		Glass sand included with sand and gravel since 1947. Quartz included with miscellaneous stone since 1954.
Manganese ore	1887	9,155,982	1,201,807	1954	1954	Riverside, Trinity, Lake, San Luis Obispo	Output intermittent.
Bromine	1926	8,503,340	b	1955	1944	San Bernardino, Alameda	California ranks third in output among the states.
Sulfur, by-product	1950	7,325,351	b	1955	1955	Los Angeles, Contra Costa, San Luis Obispo	A by-product from the refining of petroleum and not necessarily originating in county where reported.
Paving blocks	1887	c, d5,712,288		1912	1912		No longer used as pavement.
Dolomite	1915	c, d4,971,453		1946	1945	Monterey, San Benito, Tuolumne	A large percent of output goes into the reduction of magnesia from sea water.
Sulfur	1865	4,909,327	b	1955	1955	Alpine, Inyo	California ranks third in output among the states.
Sandstone	1887	c, d4,700,255		1903	1904	Monterey	Dimension stone production has decreased in recent years.
Bituminous rock	1887	4,650,320		1888	1910		A possible future source of oil.
Calcium chloride	1921	4,319,499	b	1955	1955	San Bernardino	California ranks second in output among the states.
Barite	1910	3,785,561	b	1947	1948	Tulare	Production irregular in recent years.
Lithium compounds	1899	3,752,313	b	1955	1955	San Bernardino	California ranks third in output among the states.
Bentonite	1899	c3,703,611		1928	1928	Inyo, San Bernardino, Imperial	1947-55 output included with raw clay.
Marble	1887	c, d3,587,755		1928	----		Production declined due to increased use of artificial stone.
Molybdenum ore	1916	3,481,120	b	1943	1943	Inyo	By-product of tungsten mining.
Gem minerals	1900	3,381,532	b	1943	----	San Diego, San Benito, Riverside	1948-49 output not included in total.
Slate	1889	2,291,177	b	1955	----	El Dorado	Used mostly as granules and fillers.
Carbon dioxide	1894	2,125,404	b	1944	1944	Mendocino	California ranks third in output among the states.
Feldspar	1910	1,512,980	b	1955	1955	Monterey, San Bernardino	Output has increased in recent years.
Platinum group metals	1887	1,318,234	b	1932	1940	Sacramento, Yuba	California ranks first in output among the states.
Peat	1935	1,073,855	b	1955	1955	Contra Costa, Orange, Modoc	Sold as a soil conditioner.
Sillimanite group	1922	969,919		1926	1926	Mono, Imperial (in past)	No output since 1946.
Perlite (crude)	1946	562,316	125,113	1955	1955	San Bernardino, Inyo, Napa	Early production included with pumice.
Grinding mill pebbles	1915	358,677		1916	1917	San Diego (in past)	Output was small.
Mineral paint	1890	249,038		1893	1903		Output small and irregular.
Mica	1902	248,117	b	1947	1947	Imperial	Output is of sericite variety.
Antimony ore	1887	227,096		1916	1916		Output negligible.
Asbestos	1887	221,147	b	1955	1955	Napa, Inyo, Placer	California ranks fourth among the states.
Strontium	1916	217,983	4,425	1943	1943	San Bernardino	California is the only producing state in U. S.
Titanium ore	1927	185,580	b	1928	1928	Los Angeles	Several ilmenite occurrences are known in California.
Onyx and travertine	1887	c, d122,219		1894	----		Output irregular.

Value of total recorded production in California by substances to and including 1955—continued.

Mineral products in order of total value	Year of first recorded production	Total value to 1955[a] inclusive	Value of 1955[a] output	Peak value in	Peak output in	Major producing counties in order of value of mineral output in 1955	Remarks
Shale oil	1922	109,500		1924	1924	Santa Barbara (in past)	A future source of oil.
Graphite	1901	87,495		1918	1918		Several occurrences of ore known in California.
Garnet (abrasive)	1939	74,420	b	1954	1954	Inyo	By-product from tungsten ore tailings.
Tin	1891	62,534		1892	1892		No output in recent years.
Serpentine	1896	47,218		1946	1946	Santa Clara (in past)	Now used in fertilizers.
Calcium silicate	1933	23,854		1938	1938	Kern (in past)	Used in the manufacture of mineral wool.
Cadmium	1917	16,489		1917	1917		By-product from zinc ores.
Fluorspar	1917	10,937	b	1944	1944	Riverside	Output has been intermittent.
Bismuth	1904	2,400		1904	1904		
Arsenic	1924	1,356		1924	1924		Production reported only in 1924.
Zircon sand	1932	1,310		1941	1941		Small amounts found in most black sands.
Alum minerals	1938	160		1938	----		Occurrences have been noted in several California locations.
Rare earth minerals	1952	b	b	1953	1953	San Bernardino	California has sizeable deposits of rare earth elements.
Total value for 1955			$1,458,729,633				
Total recorded value to and including 1955		$23,492,857,959					

[a] 1947 to 1955 production figures compiled by the U. S. Bureau of Mines. Previous statistics by the California Division of Mines.
[b] Figures appear only in the state total to conceal the value of an individual's output.
[c] Total value to 1946 inclusive.
[d] 1947 to 1955 values included with miscellaneous stone.

California mineral production in 1954.

Mineral commodity		Quantity	Value
Boron minerals	short tons	790,449	$26,714,440
Cement	barrels	32,761,990	98,251,245
Chromite ore and concentrates	short tons	30,661	2,285,250
Clay (raw)	short tons	1,814,420	3,559,654
Copper	pounds	724,000	213,580
Gold	fine ounces	237,886	8,326,010
Gypsum	short tons	1,161,502	2,803,862
Iron ore	long tons	1,270,292	*
Lead	pounds	5,342,000	731,854
Lime	short tons	212,381	3,387,981
Magnesium compounds	short tons	40,969	2,715,689
Manganese ore and concentrates over 35% Mn	tons	8,513	617,284
Manganese ore and concentrates under 35% Mn	tons	25,190	926,675
Mercury	flasks	11,262	2,977,560
Natural gas	M cubic feet	507,289,000	104,502,000
Natural gas liquids			
Natural gasoline and cycle products	barrels	21,980,000	89,293,000
Liquefied petroleum gases	barrels	9,433,000	22,262,000
Perlite (crude)	short tons	14,811	103,148
Petroleum	barrels	355,865,000	907,460,000
Pumice and volcanic ash	short tons	70,964	421,208
Salt	short tons	1,185,844	6,126,194
Sand and gravel	short tons	70,524,612	68,138,578
Silver	fine ounces	309,575	280,181
Stone (miscellaneous)	short tons	13,736,565	20,311,567
Talc, soapstone, pyrophyllite	short tons	133,474	1,211,201
Tungsten concentrates (60% WO_3)	short tons	3,512	13,209,371
Volcanic cinders	short tons	495,700	230,430
Zinc	pounds	2,830,000	305,640
Unapportioned*			43,737,591
Total value for 1954			$1,431,103,193

* Includes asbestos, barite, bromine, calcium chloride, carbon dioxide, coal (lignite), diatomite, feldspar, garnet, gemstones, ilmenite, iodine, iron ore, lithium compounds, magnesite, marl, mica (scrap), molybdenum concentrates, peat, platinum group metals, potassium salts, pyrites, rare earth concentrates, slate, sodium carbonate and sulfate, sulfur ore and by-product sulfur, strontium minerals.

MINERAL PRODUCTION IN COUNTIES OF CALIFORNIA DURING 1955

California is divided into 58 counties, each one of which contributed to the total value of mineral production during 1955. Each of the 16 leading counties produced minerals valued at over $10,000,000, and the total production of this group of counties comprised over 86 percent of the total value of the state mineral production.

Nevertheless some of the counties with smaller production totals provided minerals which occupy an important place in the state's economy. Included in the latter group is the production of sulfur ore from Alpine County and the production of pyrite from Shasta County for use in the manufacture of sulfuric acid; the production of lignite from Amador County for use in the manufacture of waxes; the production of mercury from Sonoma, Lake, San Benito, and San Mateo Counties; gold production from the deep lode mines of Nevada and Sierra Counties, from Siskiyou County and from the bucket-line dredges of Yuba County; gypsum and manganese ore production from Imperial County; pumice from Siskiyou, Modoc, Lassen, and Mono Counties; dimension granite from San Diego County, and Placer County; chromite from Del Norte, Butte, and Siskiyou Counties; tungsten concentrates from Mono, Tulare, and Madera Counties; oyster shells for cement from San Mateo County.

Mineral production by counties, 1955.

Alameda County

Product		Quantity	Value
Clay	short tons	44,032	$29,144
Sand and gravel	short tons	7,321,999	7,955,858
Stone (crushed)	short tons	1,313,055	1,018,134
Unapportioned*			7,308,287
Total value			$16,311,423

* Includes bromine, chromite, magnesium compounds, natural gas, and salt.

Alpine County

Mineral output of Alpine County consisted of sand and gravel, sulfur ore, and tungsten concentrates.

Amador County

Clay	short tons	134,791	$516,179
Copper	pounds	353,600	131,893
Lead	pounds	9,500	1,416
Unapportioned*			622,344
Total value			$1,271,832

* Includes coal, gemstones, gold, sand and gravel, silver, and stone (crushed).

Butte County

Gold	fine ounces	90	$3,150
Natural gas	M cubic feet	6,034,000	1,339,525
Sand and gravel	short tons	672,499	779,418
Silver	fine ounces	11	10
Unapportioned*			162,482
Total value			$2,284,585

* Includes chromite and stone (crushed).

Calaveras County

Copper	pounds	17,500	$6,527
Gold	fine ounces	399	13,965
Silver	fine ounces	64	58
Unapportioned*			9,994,209
Total value			$10,014,759

* Includes cement, lead, sand and gravel, and tungsten concentrates.

Colusa County

Sand and gravel	short tons	344,383	$314,123
Unapportioned*			37,123
Total value			$351,246

* Includes chromite and natural gas

Contra Costa County

Sand and gravel	short tons	117,649	$126,555
Stone (crushed)	short tons	1,597,564	2,153,561
Unapportioned*			1,615,596
Total value			$3,895,712

* Includes clay, natural gas, peat, and sulfur (by-product of petroleum refining).

Mineral production by counties, 1955.—Continued.

Del Norte County

Product		Quantity	Value
Chromite	short tons	2,792	$267,372
Gold	fine ounces	4	140
Sand and gravel	short tons	305,666	294,802
Silver	fine ounces	1	1
Stone (crushed)	short tons	75,750	77,100
Total value			$639,415

El Dorado County

Product		Quantity	Value
Copper	pounds	4,800	$1,790
Gold	fine ounces	6,745	236,075
Lead	pounds	45,000	6,705
Sand and gravel	short tons	172,689	154,711
Silver	fine ounces	3,238	2,931
Stone (crushed)	short tons	204,036	621,826
Zinc	pounds	19,100	2,349
Unapportioned*			1,035,997
Total value			$2,062,384

* Includes chromite, gemstones, lime, limestone, slate, soapstone, and tungsten concentrates.

Fresno County

Product		Quantity	Value
Gold	fine ounces	203	$7,105
Natural gas	M cubic feet	36,490,000	8,100,805
Natural gas liquids	barrels	2,918,000	10,123,000
Petroleum	barrels	36,292,000	91,136,898
Sand and gravel	short tons	992,151	1,053,145
Silver	fine ounces	31	28
Stone	short tons	304,489	277,039
Tungsten concentrates	pounds	165,014	333,071
Unapportioned*			411,690
Total value			$111,442,781

* Includes chromite, clay, marl, and mercury.

Glenn County

Product		Quantity	Value
Sand and gravel	short tons	368,273	$279,379
Unapportioned*			349,104
Total value			$628,483

* Includes chromite and natural gas.

Humboldt County

Product		Quantity	Value
Sand and gravel	short tons	715,075	$570,611
Stone (crushed)	short tons	21,550	17,475
Unapportioned*			512,431
Total value			$1,100,517

* Includes chromite, clay, natural gas, manganese ore (35% + Mn), and petroleum.

Imperial County

Product		Quantity	Value
Manganese ore (35% + Mn)	long tons	605	$49,238
Manganiferous ore (35% — Mn)	long tons	13,393	497,758
Sand and gravel	short tons	482,658	331,739
Unapportioned*			1,843,040
Total value			$2,721,775

* Includes clay (bentonite), gemstones, gold, gypsum, scrap mica, pumice, silver, stone (crushed), and tungsten concentrates.

Mineral production by counties, 1955.—Continued.

Inyo County

Product		Quantity	Value
Clay (includes bentonite and fullers earth)	short tons	15,125	$85,818
Copper	pounds	821,100	306,270
Gold	fine ounces	1,787	62,545
Lead	pounds	16,383,900	2,441,201
Pumice and volcanic cinders	short tons	144,976	472,705
Sand and gravel	short tons	216,068	178,618
Silver	fine ounces	838,412	758,805
Talc and pyrophyllite	short tons	64,102	786,209
Zinc	pounds	13,594,500	1,672,124
Unapportioned*			10,498,885
Total value			$17,163,180

* Includes asbestos, borates, garnet, gemstones, manganiferous ore (35% — Mn), mercury, molybdenum concentrates, perlite (crude), sodium carbonate, stone (crushed), sulfur ore, and tungsten concentrates.

Kern County

Clay (includes oil well drilling mud)	short tons	46,315	$456,115
Copper	pounds	200	75
Gold	fine ounces	4,574	160,090
Gypsum	short tons	301,517	552,318
Natural gas	M cubic feet	104,638,000	23,229,754
Natural gas liquids	barrels	7,453,000	30,492,000
Petroleum	barrels	94,455,000	233,512,222
Sand and gravel	short tons	923,785	1,205,055
Silver	fine ounces	29,262	26,484
Stone (crushed)	short tons	188,119	518,237
Tungsten concentrates	pounds	153,666	292,292
Unapportioned*			35,407,972
Total value			$325,852,614

* Includes borates, cement, gemstones, pumice, salt, sodium carbonate, and sodium sulfate.

Kings County

Natural gas	M cubic feet	10,122,000	$2,247,028
Natural gas liquids	barrels	549,000	1,940,000
Petroleum	barrels	2,668,000	8,123,721
Unapportioned*			274,288
Total value			$12,585,037

* Includes gypsum, mercury, sand and gravel, and stone (crushed).

Lake County

Mineral output of Lake County consisted of chromite, gemstones, manganese ore (35% + Mn), manganiferous ore (35% — Mn), mercury, pumice and volcanic cinders, sand and gravel, and stone (crushed), valued at $777,282.

Lassen County

Sand and gravel	short tons	349,036	$210,945
Unapportioned*			90,680
Total value			$301,625

* Includes granite, crushed stone, and volcanic cinders.

Mineral production by counties, 1955.—Continued.

Los Angeles County

Product		Quantity	Value
Clay	short tons	586,811	$641,734
Gold	fine ounces	393	13,755
Natural gas	M cubic feet	106,348,000	23,609,687
Natural gas liquids	barrels	8,092,000	31,053,000
Petroleum	barrels	91,344,000	237,106,571
Sand and gravel	short tons	18,792,178	17,564,223
Silver	fine ounces	92	83
Stone (crushed)	short tons	2,424,990	2,910,651
Unapportioned*			5,543,927
Total value			$318,443,631

* Includes cement, diatomite, iodine, by-product sulfur, soapstone, tungsten concentrates, and titanium concentrates.

Madera County

Product		Quantity	Value
Gold	fine ounces	15	$52
Natural gas	M cubic feet	2,625,000	582,855
Sand and gravel	short tons	96,315	61,178
Silver	fine ounces	3	3
Unapportioned*			994,326
Total			$1,638,887

* Includes granite, pumice and pumicite, stone (crushed), tungsten concentrates.

Marin County

Mineral output of Marin County consisted of clay, gemstones, mercury, sand and gravel, crushed stone, and tungsten concentrates, valued at $1,388,526.

Mariposa County

Product		Quantity	Value
Gold	fine ounces	606	$21,210
Sand and gravel	short tons	77,332	146,259
Silver	fine ounces	162	148
Zinc	pounds	100	12
Unapportioned*			17,479
Total value			$185,108

* Includes slate and tungsten concentrates.

Mendocino County

Product		Quantity	Value
Sand and gravel	short tons	303,596	$447,625
Unapportioned*			92,364
Total value			$447,625

* Includes carbon dioxide gas, gemstones, manganese ore (35% + Mn), and stone (crushed).

Merced County

Product		Quantity	Value
Gold	fine ounces	1	$35
Sand and gravel	short tons	951,617	1,057,909
Unapportioned*			3,764
Total value			$1,061,708

* Includes gypsum and mercury.

Modoc County

Product		Quantity	Value
Pumice and volcanic cinders	short tons	37,492	$62,445
Sand and gravel	short tons		182,685
Unapportioned			4,613
Total value			$249,743

Mineral production by counties, 1955.—Continued.

Mono County

Product		Quantity	Value
Pumice	short tons	18,955	$106,827
Sand and gravel	short tons	105,611	88,740
Unapportioned*			4,228,970
Total value			$4,424,537

* Includes clay, gemstones, gold, silver, pyrophyllite, and tungsten concentrates.

Monterey County

Natural gas	M cubic feet	8,091,000	$1,796,133
Petroleum	barrels	10,972,000	16,425,890
Sand and gravel	short tons	631,173	1,411,625
Stone (crushed and dimension)	short tons	61,143	267,621
Unapportioned*			4,847,211
Total value			$24,748,480

* Includes feldspar, gemstones, lime, magnesium compounds, salt and silica sand.

Napa County

Sand and gravel	short tons	167,115	$120,055
Stone (crushed)	short tons	722,549	998,170
Unapportioned*			151,051
Total value			$1,269,276

* Includes asbestos, chromite, diatomite, gemstones, mercury, perlite (crude).

Nevada County

Gold	fine ounces	51,792	$1,812,720
Sand and gravel	short tons	39,141	35,773
Silver	fine ounces	14,724	13,326
Unapportioned*			156,703
Total value			$2,018,522

* Includes copper, gemstones, lead, tungsten concentrates, and zinc.

Orange County

Clay	short tons	41,918	$155,885
Natural gas	M cubic feet	39,731,000	8,820,335
Natural gas liquids	barrels	3,205,000	12,663,000
Petroleum	barrels	41,754,000	103,345,839
Sand and gravel	short tons	4,585,285	3,844,108
Unapportioned*			661,688
Total value			$129,490,855

* Includes iodine, peat, salt and stone (crushed).

Placer County

Gold	fine ounces	191	$6,685
Sand and gravel	short tons	149,149	161,014
Silver	fine ounces	21	19
Unapportioned*			366,081
Total value			$533,799

* Includes asbestos, chromite, clay, gemstones, and dimension stone.

Mineral production by counties, 1955.—Continued.

Plumas County

Product		Quantity	Value
Copper	pounds	600	$224
Gold	fine ounces	113	3,955
Sand and gravel	short tons	201,595	122,263
Silver	fine ounces	79	71
Unapportioned*			12,935
Total value			$138,935

* Includes manganese (35% + Mn), stone (crushed), and soapstone.

Riverside County

Product		Quantity	Value
Clay	short tons	239,456	$639,503
Manganese ore (35% + Mn)	long tons	3,692	291,130
Sand and gravel	short tons	859,236	1,337,400
Stone (crushed)	short tons	288,340	548,896
Unapportioned*			26,730,614
Total value			$29,547,543

* Includes asbestos, cement, copper, fluorspar, gemstones, gold, gypsum, iron ore, manganiferous ore (35% — Mn), silver, and tungsten concentrates.

Sacramento County

Product		Quantity	Value
Gold	fine ounces	55,760	$1,951,670
Natural gas	M cubic feet	60,467,000	13,423,830
Sand and gravel	short tons	3,549,000	3,844,078
Silver	fine ounces	2,444	2,212
Unapportioned*			64,703
Total value			$19,286,493

* Includes clay and platinum group metals.

San Benito County

Product		Quantity	Value
Sand and gravel	short tons	178,845	$95,089
Unapportioned*			4,951,815
Total value			$5,046,904

* Includes cement, chromite, gemstones, mercury, natural gas, petroleum, and crushed stone.

San Bernardino County

Product		Quantity	Value
Clay, includes bentonite	short tons	50,956	$310,420
Copper	pounds	18,800	7,012
Gold	fine ounces	113	3,955
Lead	pounds	87,700	13,067
Sand and gravel	short tons	2,657,200	2,731,792
Silver	fine ounces	2,649	2,397
Stone, crushed and dimension	short tons	591,268	2,487,763
Talc and pyrophyllite	short tons	57,672	664,245
Tungsten concentrate	pounds	551,071	1,031,985
Zinc	pounds	46,600	5,732
Unapportioned*			65,080,779
Total value			$72,339,147

* Includes borates, bromine, calcium chloride, cement, feldspar, gemstones, iron ore, lime, lithium compounds, manganiferous ore (35% — Mn), natural gas, perlite (crude), petroleum, potassium salts, pumice and volcanic cinders, rare earth minerals, salt, sodium carbonate, sodium sulfate, and strontium minerals.

Mineral production by counties, 1955.—Continued.

San Diego County

Product		Quantity	Value
Sand and gravel	short tons	2,793,511	$4,557,591
Stone, dimension and crushed	short tons	164,714	397,803
Unapportioned*			501,336
Total value			$5,456,730

* Includes clay, gemstones, gold, magnesium salts, salt, pyrophyllite and tungsten concentrates.

San Francisco County

Mineral output of San Francisco County included gemstones, sand and gravel, and crushed stone.

San Joaquin County

Natural gas	M cubic feet	1,974,000	$438,208
Sand and gravel	short tons	1,998,700	1,747,066
Unapportioned*			28,100
Total value			$2,213,374

* Includes clay, manganese ore (35% + Mn) and manganiferous ore (35% — Mn).

San Luis Obispo County

Chromite ore and concentrates	short tons	7,172	$482,367
Natural gas	M cubic feet	1,947,000	432,208
Natural gas liquids	barrels	365,000	1,176,000
Petroleum	barrels	2,803,000	8,533,667
Sand and gravel	short tons	573,954	352,602
Unapportioned*			748,981
Total value			$11,725,825

* Includes clay, gypsum, manganese ore (35% + Mn), mercury, stone (crushed), and by-product sulfur.

San Mateo County

Sand and gravel	short tons	283,037	$179,554
Stone	short tons	1,267,526	1,625,897
Unapportioned*			8,078,154
Total value			$9,883,605

* Includes cement, magnesium compounds, mercury, natural gas, petroleum, and salt.

Santa Barbara County

Natural gas	M cubic feet	22,637,000	$5,025,321
Natural gas liquids	barrels	1,467,000	5,129,000
Petroleum	barrels	30,396,000	69,815,444
Sand and gravel	short tons	585,000	844,420
Unapportioned*			11,760,607
Total value			$92,574,792

* Includes chromite, clay, diatomite, and stone (crushed).

Santa Clara County

Mercury	flasks	830	$240,991
Sand and gravel	short tons	998,667	1,059,875
Stone (crushed)	short tons	1,391,105	896,857
Unapportioned*			19,205,429
Total value			$21,403,152

* Includes cement, chromite, clay, magnesite, and petroleum.

Mineral production by counties, 1955.—Continued.

Santa Cruz County

Product		Quantity	Value
Sand and gravel	short tons	706,525	$672,847
Unapportioned*			7,380,076
Total value			$8,052,923

* Includes cement, limestone, potassium salts, and stone (crushed).

Shasta County

Product		Quantity	Value
Copper	pounds	3,900	$1,455
Gold	fine ounces	334	11,690
Lead	pounds	3,100	462
Volcanic cinders	short tons	86,467	49,339
Sand and gravel	short tons	612,677	581,396
Silver	fine ounces	479	434
Zinc	pounds	8,200	1,009
Unapportioned*			1,080,627
Total value			$1,726,412

* Includes chromite, pyrite, stone (crushed), and tungsten concentrates.

Sierra County

Product		Quantity	Value
Gold	fine ounces	18,395	$643,825
Sand and gravel	short tons	37,925	60,764
Silver	fine ounces	3,649	3,303
Zinc	pounds	1,400	172
Total value			$708,064

Siskiyou County

Product		Quantity	Value
Chromite	short tons	2,468	$249,303
Gold	fine ounces	21,916	767,060
Pumice and volcanic cinders	short tons	362,805	154,093
Sand and gravel	short tons	193,436	163,197
Silver	fine ounces	43,518	39,386
Stone	short tons	61,633	159,694
Other minerals			448
Total value			$1,533,181

Solano County

Product		Quantity	Value
Natural gas	M cubic feet	38,495,000	$8,546,002
Sand and gravel	short tons	453,229	282,117
Stone (crushed)	short tons	143,000	213,759
Other minerals			294,550
Total value			$9,336,428

Sonoma County

Product		Quantity	Value
Sand and gravel	short tons	1,380,124	$1,366,846
Stone (crushed)	short tons	235,041	375,499
Unapportioned*			688,687
Total value			$2,431,032

* Includes manganese ore (35% + Mn), mercury, natural gas, petroleum.

Stanislaus County

Product		Quantity	Value
Sand and gravel	short tons	506,147	$456,036
Unapportioned*			25,813
Total value			$481,849

* Includes clay, gold, manganese ore (35% + Mn), manganiferous ore (35% — Mn), and mercury.

Mineral production by counties, 1955.—Continued.

Sutter County

Product		Quantity	Value
Sand and gravel	short tons	106,209	$75,556
Unapportioned			305,427
Total value			$380,983

Tehama County

Product		Quantity	Value
Chromite	short tons	593	$54,639
Natural gas	M cubic feet	1,545,000	343,082
Sand and gravel	short tons	110,443	374,674
Stone (crushed)	short tons	6,148	29,314
Total value			$801,709

Trinity County

Product		Quantity	Value
Gold	fine ounces	7,105	$248,675
Sand and gravel	short tons	68,435	55,351
Silver	fine ounces	758	686
Unapportioned*			141,584
Total value			$446,296

* Includes chromite, manganese ore (35% + Mn), manganiferous ore (35% — Mn), mercury and stone (crushed).

Tulare County

Product		Quantity	Value
Natural gas	M cubic feet	6,398,000	$1,420,470
Tungsten concentrates	pounds	248,898	474,813
Unapportioned*			1,123,051
Total value			$3,018,334

* Includes barite, clay (raw), gemstones, petroleum, sand and gravel, and stone (crushed).

Tuolumne County

Product		Quantity	Value
Sand and gravel	short tons	68,951	$149,377
Stone (crushed)	short tons	120,261	461,669
Unapportioned*			567,971
Total value			$1,179,017

* Includes chromite, gold, lime, limestone, silver, and tungsten concentrates.

Ventura County

Product		Quantity	Value
Clay	short tons	113,768	$145,116
Natural gas	M cubic feet	82,113,000	18,229,162
Natural gas liquids	barrels	5,242,000	15,837,000
Petroleum	barrels	43,914,000	118,492,977
Sand and gravel	short tons	4,021,006	3,764,249
Stone (crushed)	short tons	198,856	428,895
Other minerals	short tons	198,856	73,515
Total value			$156,970,914

Yolo County

Product		Quantity	Value
Natural gas	M cubic feet	2,227,000	$494,316
Sand and gravel	short tons	878,698	806,218
Total value			$1,300,534

Yuba County

Product		Quantity	Value
Sand and gravel	short tons	431,625	$513,202
Unapportioned*			2,853,865
Total value			$3,367,067

* Includes clay, gold, platinum group metals, and silver.

Value of mineral output in California for 1955 by counties.

County	Value	County	Value
Alameda	$16,311,423	Plumas	$138,935
Alpine and San Francisco	1,778,332	Riverside	29,547,543
Amador	1,271,832	Sacramento	19,286,493
Butte	2,284,585	San Benito	5,046,904
Calaveras	10,014,759	San Bernardino	72,339,147
Colusa	351,246	San Diego	5,456,730
Contra Costa	3,895,712	San Francisco (see Alpine)	
Del Norte	639,415	San Joaquin	2,213,374
El Dorado	2,062,384	San Luis Obispo	11,725,825
Fresno	111,442,781	San Mateo	9,883,605
Glenn	628,483	Santa Barbara	92,574,792
Humboldt	1,100,517	Santa Clara	21,403,152
Imperial	2,721,775	Santa Cruz	8,052,923
Inyo	17,163,180	Shasta	1,726,412
Kern	325,852,614	Sierra	708,064
Kings	12,585,037	Siskiyou	1,533,181
Lake	777,282	Solano	9,336,428
Lassen	301,625	Sonoma	2,431,032
Los Angeles	318,443,631	Stanislaus	481,849
Madera	1,638,887	Sutter	380,983
Marin	1,388,526	Tehama	801,709
Mariposa	185,108	Trinity	446,296
Mendocino	447,625	Tulare	3,018,334
Merced	1,061,708	Tuolumne	1,179,017
Modoc	249,743	Ventura	156,970,914
Mono	4,424,537	Yolo	1,300,534
Monterey	24,748,480	Yuba	3,367,067
Napa	1,269,276	Not distributed by counties	294,711
Nevada	2,018,522		
Orange	129,490,855		$1,458,729,633
Placer	533,799		

MINERAL PRODUCTION IN COUNTIES OF CALIFORNIA DURING 1954

All counties of the state contributed to the total mineral production during 1954 except San Francisco. Los Angeles, an oil and gas county, was the principal producer. The next five ranking counties were also oil and gas producers, namely: Kern, Ventura, Orange, Fresno, and Santa Barbara. The rank of these counties has remained unchanged for many years.

San Bernardino County in seventh place continued to produce the most diversified variety of minerals. Included in the list were: cement, potassium salts, borates, sodium salt and rare earth minerals. Riverside County ranked eighth with the following products: iron ore, cement, sand and gravel, clay, gypsum, manganese ore. Santa Clara County ranked tenth owing to its large output of cement. Monterey and Kings Counties with oil and gas, and Sacramento County with natural gas and gold followed close behind. San Luis Obispo County was a large oil and gas producer; Alameda County was the largest producer of salt by solar evaporation. Inyo County provided silver, lead, zinc, and tungsten concentrates.

Mineral production by counties, 1954.

Alameda County

Product		Quantity	Value
Clay	short tons	28,763	$18,817
Sand and gravel	short tons	4,165,508	4,504,811
Stone (crushed)	short tons	1,230,163	939,021
Other minerals*			6,584,506
Total value			$12,047,155

* Includes bromine, chromite, magnesium compounds, and natural gas.

Alpine County

The mineral production of Alpine County included sand and gravel, sulfur ore, and tungsten concentrates, valued at $1,572,363.

Amador County

Clay	short tons	138,686	$490,312
Copper	pounds	134,400	39,648
Gold	fine ounces	692	24,220
Lead	pounds	2,300	315
Sand and gravel	short tons	39,286	17,244
Silver	fine ounces	3,292	2,979
Stone (crushed)	short tons	7,374	15,858
Other minerals*			31,551
Total value			$622,127

* Includes coal, pumice, and tungsten concentrates.

Butte County

Gold	fine ounces	130	$4,550
Natural gas	M cubic feet	4,901,592	1,010,000
Sand and gravel	short tons	849,182	1,030,391
Silver	fine ounces	26	24
Stone (crushed)	short tons	57,669	23,495
Other minerals			107,331
Total value			$2,175,791

Calaveras County

Gold	fine ounces	824	$28,840
Silver	fine ounces	146	132
Other minerals*			8,426,671
Total value			$8,455,643

* Includes cement, clay, pumice, sand and gravel, crushed stone, and tungsten concentrates.

Colusa County

The mineral production of Colusa County included chromite, natural gas, and sand and gravel, valued at $88,409.

Contra Costa County

Sand and gravel	short tons	516,912	$507,978
Stone (crushed)	short tons	851,581	1,195,252
Other minerals*			1,003,696
Total value			$2,706,926

* Includes clay, mercury, natural gas, peat, potassium salts and by-product sulfur.

Del Norte County

Chromite ore and conc.	short tons	4,135	$335,701
Sand and gravel	short tons	730,315	393,248
Stone (crushed)	short tons	146,509	620,561
Other minerals			264
Total value			$1,349,774

Mineral production by counties, 1954.—Continued.

El Dorado County

Product		Quantity	Value
Chromite	short tons	449	$35,457
Copper	pounds	98,800	29,146
Gold	fine ounces	6,309	220,815
Lead	pounds	72,300	9,905
Sand and gravel	short tons	84,727	69,756
Silver	fine ounces	5,090	4,607
Stone (crushed)	short tons	388,054	725,459
Zinc	pounds	43,300	4,676
Other minerals*			731,488
Total value			$1,831,309

* Includes lime, limestone, slate, soapstone, and tungsten concentrates.

Fresno County

Gold	fine ounces	179	$6,265
Natural gas	M cubic feet	34,853,694	7,180,000
Natural gas liquids	barrels	2,934,000	9,518,696
Petroleum	barrels	34,643,000	98,556,000
Sand and gravel	short tons	1,245,458	1,213,555
Silver	fine ounces	27	24
Stone (crushed)	short tons	503,703	510,492
Other minerals*			677,842
Total value			$117,622,874

* Includes chromite, clay, marl, mercury, pumice, and tungsten concentrates.

Glenn County

Sand and gravel	short tons	485,929	$289,594
Other minerals			188,953
Total value			$478,547

Humboldt County

Sand and gravel	short tons	702,624	$604,954
Stone	short tons	38,741	90,845
Other minerals*			402,584
Total value			$1,098,383

* Includes chromite, clay, natural gas, and petroleum.

Imperial County

Gold	fine ounces	36	$1,260
Sand and gravel	short tons	922,857	749,286
Silver	fine ounces	11	10
Other minerals*			2,181,718
Total value			$2,932,274

* Includes carbon dioxide, clay, gypsum, manganese ore and concentrates, mica (scrap), pumice, stone (crushed), strontium minerals, and tungsten concentrates.

Inyo County

Copper	pounds	224,600	$66,257
Gold	fine ounces	766	26,810
Lead	pounds	5,253,200	719,688
Sand and gravel	short tons	92,452	65,419
Silver	fine ounces	234,254	212,012
Talc	short tons	48,481	484,106
Tungsten concentrates	short tons	1,710	7,556,575
Zinc	pounds	2,771,100	299,279
Other minerals*			1,103,480
Total value			$10,533,626

* Includes borates, clay (raw, bentonite, and fullers earth), manganese ore, molybdenum concentrates, perlite, pumice and pumicite, and sodium carbonate, and volcanic cinders.

Mineral production by counties, 1954.—Continued.

Kern County

Product		Quantity	Value
Clay	short tons	46,266	$433,994
Gold	fine ounces	5,695	199,325
Gypsum	short tons	245,486	424,245
Natural gas	M cubic feet	97,399,119	20,064,000
Natural gas liquids	barrels	8,809,000	30,508,600
Petroleum	barrels	91,110,000	225,152,000
Sand and gravel	short tons	659,508	797,214
Silver	fine ounces	14,065	12,730
Stone (crushed)	short tons	106,535	259,873
Tungsten concentrates	short tons	61	239,375
Other minerals*			28,335,539
Total value			$306,426,895

* Includes borates, cement, feldspar, limestone, manganese ore, pumice, and salt.

Kings County

Natural gas	M cubic feet	26,723,945	$5,505,000
Petroleum	barrels	2,774,000	8,788,000
Other minerals*			4,864,133
Total value			$19,157,133

* Includes gypsum, natural gas liquids, sand and gravel, and stone (crushed).

Lake County

Sand and gravel	short tons	181,353	$130,869
Other minerals*			640,124
Total value			$770,993

* Includes chromite, manganese ore, mercury, pumice, stone (crushed), and volcanic cinders.

Lassen County

Sand and gravel	short tons	106,020	$95,008
Other minerals*			100,189
Total value			$195,197

* Includes granite, stone (crushed), tungsten concentrates, and volcanic cinders.

Los Angeles County

Clay	short tons	589,767	$417,978
Gold	fine ounces	197	6,895
Natural gas	M cubic feet	90,672,811	18,679,000
Natural gas liquids	barrels	7,471,000	28,761,070
Petroleum	barrels	92,972,000	248,160,000
Sand and gravel	short tons	25,359,979	23,010,654
Silver	fine ounces	29	26
Stone (crushed)	short tons	3,794,661	4,616,995
Other minerals*			5,601,547
Total value			$329,254,165

* Includes cement, diatomite, iodine, quartz, soapstone, by-product sulfur and titanium concentrates.

Madera County

Copper	pounds	87,400	$25,783
Gold	fine ounces	253	8,855
Natural gas	M cubic feet	3,143,557	648,000
Silver	fine ounces	928	840
Zinc	pounds	100	11
Other minerals*			1,283,768
Total value			$1,967,257

* Includes granite, pumice and pumicite, sand and gravel, stone (crushed), and tungsten concentrates.

Mineral production by counties, 1954.—Continued.

Marin County

The mineral production of Marin County included clay, sand and gravel, and stone (crushed) valued at $1,277,141.

Mariposa County

Gold	fine ounces	412	$14,420
Lead	pounds	800	110
Sand and gravel	short tons	81,996	86,167
Silver	fine ounces	227	205
Zinc	pounds	600	65
Other minerals			2,773
Total value			$103,740

Mendocino County

Sand and gravel	short tons	525,645	$630,348
Other minerals*			56,641
Total value			$686,989

* Includes carbon dioxide, manganese ore, and stone (crushed).

Merced County

Sand and gravel	short tons	1,247,551	$856,870
Other minerals			3,227
Total value			$860,097

Modoc County

Sand and gravel	short tons	447,324	$310,682
Other minerals*			135,090
Total value			$445,772

* Includes peat, pumice, stone (crushed), and volcanic cinders.

Mono County

Gold	fine ounces	199	$6,965
Silver	fine ounces	1,953	1,768
Tungsten concentrates	short tons	665	2,729,463
Other minerals*			214,482
Total value			$2,952,678

* Includes clay, pumice, pyrophyllite, and sand and gravel.

Monterey County

Petroleum	barrels	11,213,000	$13,587,000
Sand and gravel, sand	short tons	1,073,455	2,381,204
Stone	short tons	101,013	240,139
Other minerals*			3,629,645
Total value			$19,837,988

* Includes dolomite, feldspar, lime, magnesium compounds, natural gas, and salt.

Napa County

Sand and gravel	short tons	19,723	$22,708
Other minerals*			1,050,932
Total value			$1,073,640

* Includes chromite, diatomite, mercury, perlite, and stone (crushed).

Mineral production by counties, 1954.—Continued.

Nevada County

Product		Quantity	Value
Copper	pounds	4,400	$1,298
Gold	fine ounces	56,716	1,985,060
Sand and gravel	short tons	90,416	117,816
Silver	fine ounces	15,733	14,239
Other minerals			16,097
Total value			$2,134,510

Orange County

Product		Quantity	Value
Clay	short tons	38,792	$119,083
Copper	pounds	100	30
Gold	fine ounces	2	70
Lead	pounds	1,300	178
Natural gas	M cubic feet	34,719,345	7,152,000
Natural gas liquids	barrels	4,406,000	15,996,492
Petroleum	barrels	37,824,000	93,363,000
Sand and gravel	short tons	3,681,772	3,424,748
Silver	fine ounces	632	572
Zinc	pounds	7,900	853
Other minerals*			609,600
Total value			$120,666,626

* Includes clay, peat, salt, and crushed stone.

Placer County

Product		Quantity	Value
Gold	fine ounces	472	$16,520
Sand and gravel	short tons	130,114	106,082
Silver	fine ounces	46	42
Other minerals*			318,011
Total value			$440,655

* Includes asbestos (amphibole), clay, granite, and stone (crushed).

Plumas County

Product		Quantity	Value
Copper	pounds	1,500	$442
Gold	fine ounces	255	8,925
Silver	fine ounces	307	278
Other minerals*			101,450
Total value			$111,095

* Includes chromite, sand and gravel, and stone (crushed).

Riverside County

Product		Quantity	Value
Copper	pounds	600	$177
Gold	fine ounces	6	210
Lead	pounds	800	110
Manganese ore and concentrates	long tons	8,087	410,884
Sand and gravel	short tons	829,918	1,302,672
Silver	fine ounces	42	38
Other minerals*			22,970,934
Total value			$24,685,025

* Includes asbestos, cement, clay, granite, gypsum, iron ore, limestone, stone (crushed), talc, and tungsten concentrates.

Sacramento County

Product		Quantity	Value
Clay	short tons	19,068	$24,322
Gold	fine ounces	61,866	2,165,310
Natural gas	M cubic feet	52,676,243	10,851,000
Sand and gravel	short tons	5,244,901	4,979,181
Silver	fine ounces	2,620	2,371
Other minerals			6,720
Total value			$18,028,904

Mineral production by counties, 1954.—Continued.

San Benito County

Product		Quantity	Value
Mercury	flasks	5,255	$1,389,370
Other minerals*			3,436,285
Total value			$4,825,655

* Includes cement, chromite, bentonite, dolomite, manganese ore, natural gas, petroleum, sand and gravel, and stone (crushed).

San Bernardino County

Clay	short tons	49,530	$300,279
Copper	pounds	90,200	26,609
Gold	fine ounces	1,208	42,280
Lead	pounds	10,500	1,438
Manganese ore and concentrate	long tons	6,206	329,848
Sand and gravel	short tons	4,278,413	3,666,511
Stone (crushed)	short tons	312,050	1,562,239
Silver	fine ounces	3,832	3,468
Talc	short tons	55,635	642,524
Zinc	pounds	5,800	626
Other minerals*			60,888,513
Total value			$67,464,335

* Includes borate, bromine, calcium chloride, cement, feldspar, granite, lime, limestone, lithium compounds, perlite, petroleum, potash, pumice, rare earths, sodium carbonate, sodium sulfate, tungsten concentrates, volcanic cinders and salt.

San Diego County

Gold	fine ounces	5	$175
Granite	cubic feet	15,491	70,721
Sand and gravel	short tons	4,079,276	4,718,778
Stone (crushed)	short tons	504,570	743,987
Tungsten concentrates	short tons	10	38,486
Other minerals*			464,078
Total value			$6,036,225

* Includes clay, magnesium chloride, pyrophyllite, salt, sand and sandstone (ground), and silver.

San Joaquin County

Natural gas	M cubic feet	5,781,610	$1,191,000
Sand and gravel	short tons	1,709,372	1,650,806
Other minerals			123,162
Total value			$2,964,968

San Luis Obispo County

Chromite ore and concentrates	short tons	13,469	$898,239
Natural gas	M cubic feet	1,054,067	217,000
Petroleum	barrels	3,185,000	9,488,000
Sand and gravel	short tons	631,903	386,996
Other minerals*			1,770,811
Total value			$12,761,046

* Includes gypsum, limestone, manganese ore, mercury, natural gas liquids, and stone (crushed).

San Mateo County

The mineral production of San Mateo County included cement, gold, limestone, magnesium compounds, salt, sand, and stone (crushed), valued at $7,741,122.

Santa Barbara County

Natural gas	M cubic feet	17,625,917	$3,631,000
Natural gas liquids	barrels	1,430,000	5,059,219
Petroleum	barrels	33,342,000	77,492,000
Sand and gravel	short tons	837,923	667,188
Other minerals*			6,470,117
Total value			$93,319,524

* Includes chromite, clay, diatomite, limestone, and stone (crushed).

Mineral production by counties, 1954.—Continued.

Santa Clara County

Product		Quantity	Value
Clay	short tons	63,128	$31,576
Mercury	flasks	271	71,650
Sand and gravel	short tons	557,974	525,119
Stone (crushed)	short tons	1,161,742	717,783
Other minerals*			21,924,710
Total value			$23,270,838

* Includes cement, chromite, magnesite, and petroleum.

Santa Cruz County

Sand and gravel	short tons	763,318	$726,470
Other minerals*			5,380,058
Total value			$6,106,528

* Includes cement, limestone, potash, and stone (crushed).

Shasta County

Sand and gravel	short tons	639,622	$582,836
Other minerals*			997,397
Total value			$1,580,233

* Includes chromite, copper, gold, iron ore, pyrites, silver, stone (crushed), and volcanic cinders.

Sierra County

Gold	fine ounces	13,393	$468,405
Silver	fine ounces	2,612	2,364
Zinc	pounds	1,200	130
Other minerals			97,198
Total value			$568,097

Siskiyou County

Chromite ore and concentrates	short tons	3,830	$345,008
Gold	fine ounces	13,971	488,985
Lead	pounds	800	110
Pumice and volcanic cinders	short tons	424,582	185,743
Sand and gravel	short tons	181,903	168,693
Silver	fine ounces	18,960	17,160
Stone (crushed)	short tons	72,000	144,905
Other minerals			3,975
Total value			$1,354,579

Solano County

Natural gas	M cubic feet	30,490,330	$6,281,000
Other minerals*			430,341
Total value			$6,711,341

* Includes clay, sand and gravel, stone (crushed).

Sonoma County

The mineral production of Sonoma County included mercury, petroleum, sand and gravel, and stone (crushed), valued at $2,528,448.

Stanislaus County

Gold	fine ounces	4	$140
Sand and gravel	short tons	487,433	594,631
Other minerals*			61,101
Total value			$655,872

* Includes clay, manganese ore, and mercury.

Mineral production by counties, 1954.—Continued.

Sutter County

Product		Quantity	Value

The mineral production of Sutter County included clay, natural gas, sand and gravel, valued at $279,824.

Tehama County

Chromite ore and concentrates	short tons	903	$71,994
Sand and gravel	short tons	358,804	324,895
Other minerals			109,000
Total value			$505,889

Trinity County

Chromite ore and concentrates	short tons	502	$35,463
Copper	pounds	10,800	3,186
Gold	fine ounces	6,126	214,410
Manganese ore	long tons	273	31,991
Sand and gravel	short tons	70,873	81,639
Silver	fine ounces	652	590
Other minerals			35,485
Total value			$402,764

Tulare County

Natural gas	M cubic feet	5,654,560	$1,165,000
Tungsten concentrates	short tons	102	416,133
Other minerals*			548,680
Total value			$2,129,813

* Includes barite, clay, petroleum, sand and gravel, and stone (crushed).

Tuolumne County

Gold	fine ounces	42	$1,470
Silver	fine ounces	6	5
Stone (crushed)	short tons	67,158	371,686
Other minerals*			512,145
Total value			$885,306

* Includes chromite, lime, limestone, sand and gravel, and tungsten ore.

Ventura County

Natural gas	M cubic feet	92,622,560	$19,080,000
Natural gas liquids	barrels	4,474,000	15,872,709
Petroleum	barrels	48,714,000	132,678,000
Sand and gravel	short tons	1,529,034	1,493,769
Other minerals*			1,044,818
Total value			$170,169,296

* Includes clay, gypsum, limestone and stone (crushed).

Yolo County

Natural gas	M cubic feet	2,672,200	$550,000
Sand and gravel	short tons	1,124,153	932,615
Total value			$1,482,615

Yuba County

Gold	fine ounces	67,956	$2,378,460
Silver	fine ounces	4,050	3,665
Other minerals*			229,872
Total value			$2,611,997

* Includes clay, platinum, sand and gravel.

Value of mineral output in California for 1954 by counties.

County	Value	County	Value
Alameda	$12,047,155	Plumas	$111,095
Alpine	1,572,363	Riverside	24,685,025
Amador	622,127	Sacramento	18,028,904
Butte	2,175,791	San Benito	4,825,655
Calaveras	8,455,643	San Bernardino	67,464,335
Colusa	88,409	San Diego	6,036,225
Contra Costa	2,706,926	San Francisco	0
Del Norte	1,349,774	San Joaquin	2,964,968
El Dorado	1,831,309	San Luis Obispo	12,761,046
Fresno	117,662,874	San Mateo	7,741,122
Glenn	478,547	Santa Barbara	93,319,524
Humboldt	1,098,383	Santa Clara	23,270,838
Imperial	2,932,274	Santa Cruz	6,106,528
Inyo	10,533,626	Shasta	1,580,233
Kern	306,426,895	Sierra	568,097
Kings	19,157,133	Siskiyou	1,354,579
Lake	770,993	Solano	6,711,341
Lassen	195,197	Sonoma	2,528,448
Los Angeles	329,254,165	Stanislaus	655,872
Madera	1,967,257	Sutter	279,824
Marin	1,277,141	Tehama	505,889
Mariposa	103,740	Trinity	402,764
Mendocino	686,989	Tulare	2,129,813
Merced	860,097	Tuolumne	885,306
Modoc	445,772	Ventura	170,169,296
Mono	2,952,678	Yolo	1,482,615
Monterey	19,837,988	Yuba	2,611,997
Napa	1,073,640	Not distributed by counties	155,177
Nevada	2,134,510		
Orange	120,666,626		$1,431,103,193
Placer	440,655		

MINERAL COMMODITIES, 1954 AND 1955

Antimony. No production or shipments of antimony ore were reported in California during 1954 and 1955. A small tonnage of ore and concentrates is held at some of the mines.

Asbestos. Asbestos produced in 1955 came from single properties in Inyo, Napa, Placer and Riverside Counties and in 1954 from single properties in Placer, Riverside and Siskiyou Counties. The material from Napa and Siskiyou Counties was chrysotile while that from Inyo, Placer and Riverside was amphibole. The Placer County material was a high grade tremolite suitable for use in filters.

Barite. Barite mined in California during 1955 came from two properties in Tulare County and one in Nevada County. The production from Tulare County was shipped to grinding plants and prepared for use in oil well drilling mud. The barite from Nevada County was stockpiled at Colfax. In 1954 the California output of barite came from Tulare County. In 1954 and 1955 only 10 percent of the barite used in California for oil well drilling mud and in the chemical industry was produced from properties within the state. The remainder was imported from Nevada mines.

Borates. California continues to be the chief source of borate minerals for world consumption. Borates produced and shipped in California during 1955 totaled 924,496 short tons valued at $33,816,464, compared with 790,449 short tons valued at $26,714,440 in 1954. The

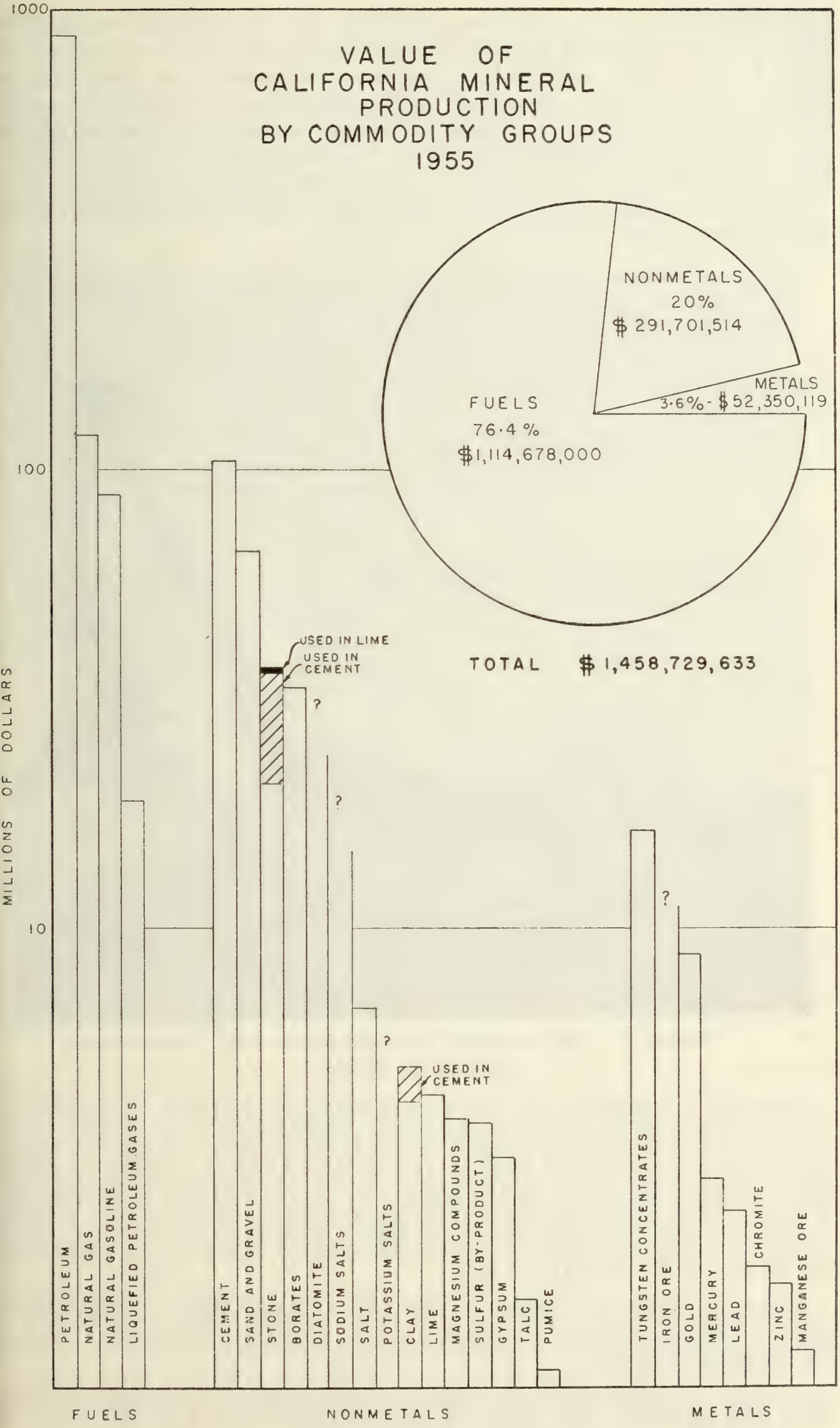


FIGURE 1. Chart showing principal mineral products, 1955.

material came from properties operated by two companies in Inyo County, two companies in San Bernardino County and one company in Kern County. The principal production was made from underground mines in the Kramer district of southeastern Kern County. The dry-lake beds of Inyo County yielded colemanite and ulexite, while the dry-lake beds of Kern County yielded borax and kernite. Borax was recovered from the dry-lake brines of San Bernardino County.

Exploration and development of a borate deposit was under way at the Western mine, near Boron, Kern County.

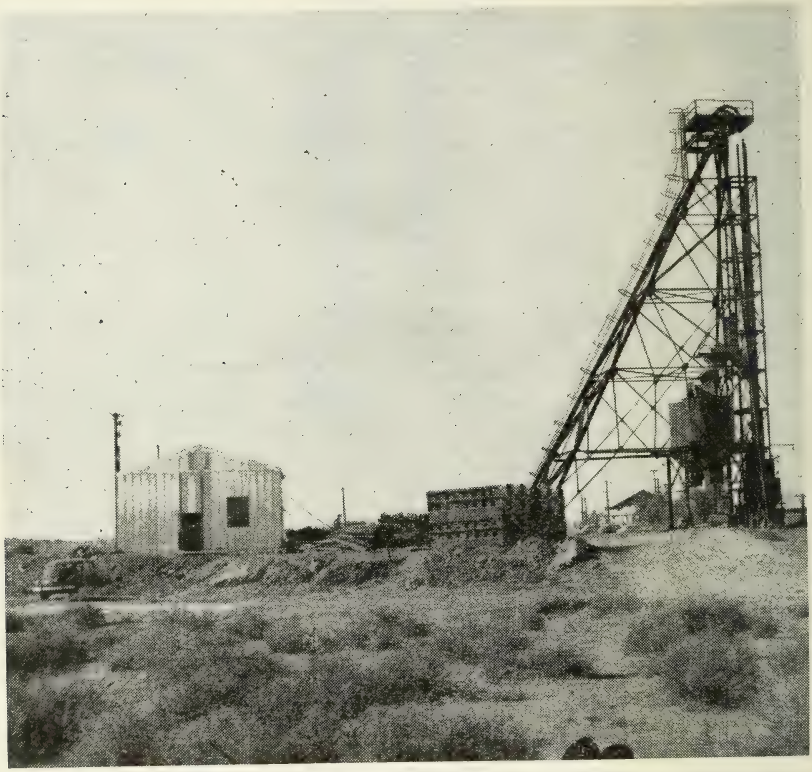


FIGURE 2. New headframe and hoist house at the Western borate mine, Kern County.

Bromine. Bromine and ethylene dibromide produced in California during 1954 and 1955 came from single properties in Alameda and San Bernardino Counties. In 1954 there was also a small tonnage of potassium bromide produced in the state. Salt water bitterns from the salt works on San Francisco Bay were the source of the Alameda County production. The production in San Bernardino County was made from the brines of Searles Dry Lake.

Calcium Chloride. Calcium chloride was produced in California during 1954 and 1955 by two companies at Bristol Dry Lake in San Bernardino County.

Cement. California is the second ranking state in cement production. The quantity and value of cement production and shipments in

California during 1955 were the highest on record. Cement produced in California totaled 35,449,534 barrels in 1955, with 16,142,248 barrels coming from northern California mills and 19,307,286 barrels coming from southern California mills. The 1955 output showed a 9 percent increase over that of 1954 which amounted to 32,598,878 barrels, of which 14,389,330 barrels came from northern California mills and 18,209,548 barrels came from southern California mills. The mills are distributed as follows: northern—one each in Calaveras, San Benito, San Mateo, Santa Clara and Santa Cruz Counties; southern—three in San Bernardino County and one each in Kern, Los Angeles and Riverside Counties.

Cement shipped and used in California during 1955 totaled 35,084,415 barrels worth $103,793,702. The five northern California mills contributed 16,030,433 barrels worth $45,256,605 and the six southern California mills supplied 19,053,982 barrels worth $58,537,097. In 1954 shipments of all types of cement totaled 32,761,990 barrels valued at $98,251,245, of which northern California mills supplied 14,406,528 barrels worth $43,026,454, and southern California mills supplied 18,355,462 barrels worth $55,224,791.

The annual capacity of all California cement mills totaled 36,220,000 barrels on December 31, 1955. Capacity of the northern California mills totaled 15,900,000 barrels and of the southern California mills totaled 20,320,000 barrels. Comparative capacity figures for December 31, 1954 were 35,845,000 barrels for all California mills, 15,225,000 barrels for the northern mills and 20,620,000 barrels for the southern mills. Two new cement mills were under construction during 1955: the California Portland Cement mill at Creel near Mojave, Kern County; and the Permanente Cement Company mill in Cushenbury Canyon, San Bernardino County. Improvement and enlargement of facilities was under way at nearly all plants throughout the state.

At the Crestmore limestone deposit of the Riverside Cement Company an underground exploration program was successfully completed during 1954 which greatly extended the life of the cement plant. As a result a modified room and pillar method of mining was installed to replace the block caving system formerly used. Raw material transportation to the surface is made by trackless trolley motor trucks rather than by mine hoists.

Chromite. Chromite, the only ore of chromium, is one of the most critical of strategic ores because it is an essential ingredient in the manufacture of a wide variety of steels. The total U. S. production has always fallen short of domestic requirements. California ranked second among the chromite-producing states in 1954 and 1955. The most productive mines are about equally distributed between the southern Coast Ranges and the Klamath Mountains. The principal chromite-producing counties are San Luis Obispo, Del Norte, El Dorado, Siskiyou, Glenn, Fresno and Shasta.

The quantity and value of chromite produced in California during 1954 were at the highest points since 1943. The 1955 output of chromite in California totaled 22,105 short tons worth $1,834,277, compared with 30,661 short tons valued at $2,285,250 in 1954. Most of the ore mined in 1954 and 1955 was shipped to the U. S. Government, General Serv-

ices Administration stockpile at Grants Pass, Oregon. The following table gives the 1954 and 1955 chromite output by counties.

FIGURE 3. Floor of open cut just before blasting. Looking north in Holiday chrome mine, Del Norte County. *Photo by J. C. O'Brien.*

Chromite produced in 1954 and 1955, by counties.

County	1954		1955	
	Short tons	Value	Short tons	Value
Del Norte	4,135	$335,701	2,792	$267,372
El Dorado	449	35,457	*	*
San Luis Obispo	13,469	898,239	7,172	482,367
Siskiyou	3,830	345,008	2,468	249,303
Tehama	903	71,994	593	54,639
Trinity	502	35,463	*	*
Other counties	[1]7,373	563,388	[2]9,080	780,596
Totals	30,661	$2,285,250	22,105	$1,834,277

* Included under "Other counties."
[1] Includes Alameda, Butte, Colusa, Fresno, Glenn, Humboldt, Lake, Napa, Placer, San Benito, Santa Barbara, Santa Clara, Shasta, and Tuolumne Counties.
[2] Includes Alameda, Butte, El Dorado, Fresno, Glenn, Humboldt, Lake, Napa, Placer, San Benito, Santa Barbara, Santa Clara, Shasta, Trinity, and Tuolumne Counties.

The 1955 chromite production was made by 114 separate operators, mining 113 properties in 19 counties. The 1954 production was made by 149 operators, mining 138 properties in 21 counties. One operator in Butte County was granted an exploration loan from the Defense Minerals Exploration Administration of the U. S. Government. The average chromic oxide (Cr_2O_3) content of California shipments was

42 percent. Sixty-three percent of the shipments was in the form of concentrate.

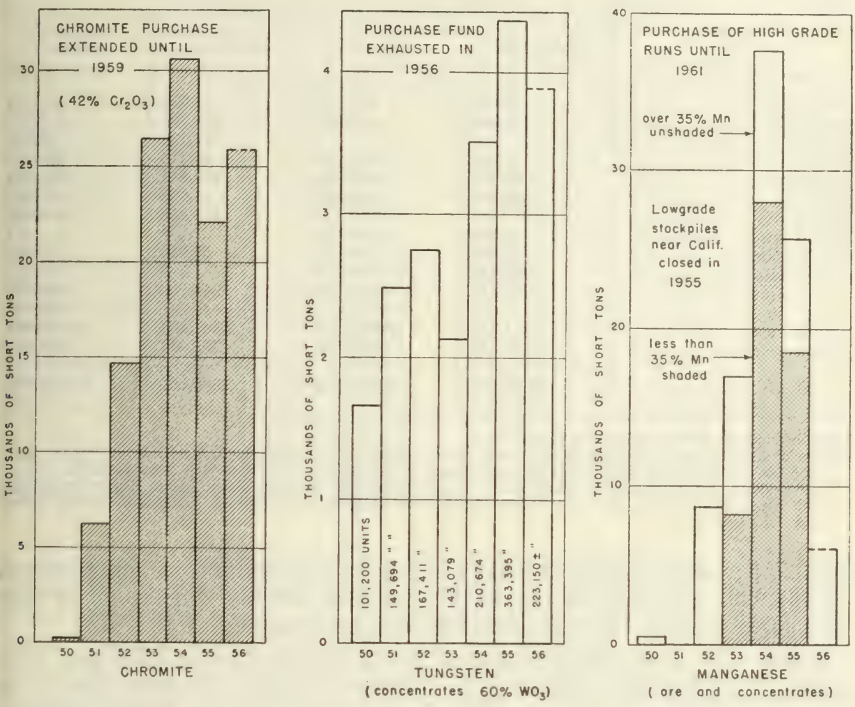


FIGURE 4. Chart showing strategic mineral production in California, 1950-56, stimulated by U.S. government purchase.

Clay. California's wealth in a diverse variety of clay raw materials coupled with its expanding population and industrial potential, has established clay products as a leading industry in the state's economy.

Crude clay (including crude clay used in the manufacture of cement) was produced in California during 1955 from 94 pits in 27 counties. Production totaled 2,860,395 short tons worth \$5,027,381. During 1954, production totaled 2,722,850 short tons worth \$4,477,174 and was produced from pits in 26 counties.

The accompanying table gives the 1954 and 1955 output of crude clay by counties.

Of the 1955 clay output in California, 31,835 short tons worth \$335,651 was kaolin or china clay; 440,320 short tons worth \$1,394,895 was fire clay; 18,404 short tons worth \$148,284 was bentonite and fullers earth; and 1,646,723 short tons worth \$2,443,644 was miscellaneous clay. Included in the total was 758,931 short tons of clay and shale used in the manufacture of cement valued at \$804,313.

Comparative figures for 1954 include 28,413 short tons of china clay and kaolin worth \$278,036; 381,392 short tons of fire clay worth \$1,196,944; 9,057 short tons of bentonite and fullers earth worth

Clay produced in 1954 and 1955, by counties.

County	1954		1955	
	Short tons	Value	Short tons	Value
Alameda	28,763	$18,817	44,032	$29,144
Amador	138,686	490,312	134,791	516,179
Inyo	*	*	15,125	85,818
Kern	46,266	433,994	46,315	456,115
Los Angeles	589,767	417,978	586,811	641,734
Orange	38,792	119,083	41,918	155,885
Riverside	*	*	239,456	639,503
Sacramento	19,068	24,322	*	*
San Bernardino	49,530	300,279	50,956	310,420
Santa Clara	63,128	31,576	*	*
Other counties	[1]840,420	1,725,293	[2]942,060	1,388,270
Subtotals	1,814,420	$3,559,654	2,101,464	$4,223,068
Used in cement	908,430	[a]917,520	758,931	[a]804,313
Totals	2,722,850	$4,477,174	2,860,395	$5,027,381

[a] Not included in state total mineral value.
[1] Other counties include, Calaveras, Contra Costa, Fresno, Humboldt, Imperial, Inyo, Marin, Mono, Placer, Riverside, San Diego, San Joaquin, Santa Barbara, Solano, Stanislaus, Sutter, Tulare, and Yuba Counties.
[2] Other counties include, Calaveras, Contra Costa, Fresno, Humboldt, Imperial, Marin, Mono, Placer, Sacramento, San Diego, San Joaquin, San Luis Obispo, Santa Barbara, Santa Clara, Solano, Stanislaus, Sutter, Tulare, and Yuba Counties.

$119,755; and 1,395,558 short tons of miscellaneous clay worth $1,964,929. Included in the 1954 total was 908,430 short tons of clay and shale used in the manufacture of cement valued at $917,520.

Coal. The coal (lignite) mined in California during 1954 and 1955 came from a single property in Amador County. It was used as a source of montan wax, van dyke brown pigment and humis. Montan wax is used in the manufacture of shoe polish, carbon paper, and as a substitute for carnauba wax. The residue after the montan wax has been extracted is used as a soil conditioner.

Copper. The copper industry in the United States was highlighted by increased consumption, inadequate supplies and rising prices during 1955. The price of electrolytic copper delivered in the United States rose from 30 cents in January to 50¼ cents per pound in December 1955. This was the highest level in 90 years. The yearly average price was 37.3 cents per pound compared with 29.5 cents per pound in 1954.

Most of the copper produced in California during recent years has been a by-product of mines worked for other metals. The copper produced during 1955 totaled 1,226,000 pounds valued at $457,298, and came from mines in Amador, Calaveras, El Dorado, Inyo, Kern, Nevada, Riverside, San Bernardino and Shasta Counties. The 1954 production totaled 724,000 pounds worth $213,580, and came from mines in Amador, El Dorado, Inyo, Madera, Orange, Nevada, Plumas, Riverside, San Bernardino and Trinity Counties. Inyo County was the largest producer of copper in 1954 and 1955 and the metal was a by-product of tungsten mining. The production in Amador County, the second largest producer, came from a copper-gold mine.

The Defense Minerals Exploration Administration approved a loan to the Providence Tuolumne Gold Mines, Ltd., to explore the Copper Bluff lease on the Hoopa Reservation in Humboldt County.

The accompanying tabulation gave the 1954 and 1955 copper output in California by counties:

Copper produced in 1954 and 1955, by counties.

County	1954		1955	
	Pounds	Value	Pounds	Value
Amador	134,400	$39,648	353,600	$131,893
Calaveras			17,500	6,527
El Dorado	98,800	29,146	4,800	1,790
Inyo	224,600	66,257	821,100	306,270
Kern			200	75
Madera	87,400	25,783		
Nevada	4,400	1,298	*	*
Orange	100	30		
Plumas	1,500	442	600	224
Riverside	600	177	*	*
San Bernardino	90,200	26,609	18,800	7,012
Trinity	10,800	3,186		
Other counties*	71,200	21,004	9,400	3,507
Total	724,000	$213,580	1,226,000	$457,298

* Other counties include Nevada, Riverside and Shasta.

Diatomite. California is the chief source and leading producer of diatomite in the United States. In 1955 the production of diatomite from California mines was the largest on record in both quantity and value. Nearly all the diatomite mined and shipped in California during 1954 and 1955 was produced by two large companies with operations in Santa Barbara County and Los Angeles County. A small production was made in Napa County. Santa Barbara was the principal producing county.

Over 50 percent of the diatomite produced is used in the filtration of sugar, beverages, water, chemicals, oils and other liquids. About 25 percent of the annual production is used as a filler in rubber, paper, plastics, explosives, paints, and other products. The remainder of the annual output is used as a heat and sound insulator, as abrasive, as a pozzolan in concrete and for many other purposes.

Feldspar. The feldspar reported shipped in California during 1954 and 1955 came from single properties in Monterey and San Bernardino Counties. The material from San Bernardino County was crude feldspar mined from a pegmatite dike 9 miles northeast of Fremont Peak. The feldspar from Monterey County was a flotation concentrate recovered as a by-product in the cleaning of dune sand for the glass industry. Most of the feldspar produced in California is used in the glass and ceramic industries, but some is used in the enamel industry, and as an abrasive in soaps and cleaners.

Fluorspar. During 1955 a small tonnage of metallurgical grade fluorspar was mined and shipped from a property in Riverside County. A property in San Bernardino County was under development but no shipments were made. In 1954 a small tonnage was produced from another property in San Bernardino County but no shipments were made.

Garnet (Abrasive). During 1954 and 1955 a considerable quantity of abrasive garnet was recovered from the tailings of tungsten mines in the area around Bishop, Inyo County. Late in 1955 the operator suspended operations owing to the slackening of demand. Some garnet was used also as a surfacing material for concrete.

Gemstones. During 1954 and 1955 much gem material was produced in California. The pegmatites of San Diego County yielded beryl, kunzite and tourmaline. The production of rhodonite was reported from Amador, Kern, Monterey and San Bernardino Counties; garnet from El Dorado and San Diego Counties; agate from Imperial, Kern, Nevada, Riverside, San Luis Obispo and Santa Clara Counties; quartz crystals from Inyo, Lake and Napa Counties; rose quartz from Riverside County; geodes from Mono County; jade from Mendocino, Monterey, Placer, San Benito and Siskiyou Counties; vesuvianite from El Dorado, Butte and Siskiyou Counties, and topaz from Tulare County.

Gold. The gold produced in California during 1955 totaled 251,737 fine ounces worth $8,810,795 compared with 237,886 fine ounces worth $8,326,010 in 1954. Of the 1955 gold output, 146,613 fine ounces worth $5,131,455 came from placers, mainly dredges, and 105,124 fine ounces worth $3,679,340 from the lode mines. In 1954 the placer mines produced 140,197 fine ounces worth $4,906,895 and the lode mines pro-

Gold produced in 1954 and 1955, by counties.

County	1954		1955	
	Fine ounces	Value	Fine ounces	Value
Amador	692	$24,220	*	*
Butte	130	4,550	90	$3,150
Calaveras	824	28,840	399	13,965
Del Norte	---	---	4	140
El Dorado	6,309	220,815	6,745	236,075
Fresno	179	6,265	203	7,105
Imperial	36	1,260	*	*
Inyo	766	26,810	1,787	62,545
Kern	5,695	199,325	4,574	160,090
Los Angeles	197	6,895	393	13,755
Madera	253	8,855	15	525
Mariposa	412	14,420	606	21,210
Merced	*	*	1	35
Mono	199	6,965	*	*
Nevada	56,716	1,985,060	51,792	1,812,720
Orange	2	70	---	---
Placer	472	16,520	191	6,685
Plumas	255	8,925	113	3,955
Riverside	6	210	*	*
Sacramento	61,866	2,165,310	55,762	1,951,670
San Bernardino	1,208	42,280	113	3,955
San Diego	5	175	*	*
Shasta	*	*	334	11,690
Sierra	13,383	468,405	18,395	643,825
Siskiyou	13,971	488,985	21,916	767,060
Stanislaus	4	140	*	*
Trinity	6,126	214,410	7,105	248,675
Tuolumne	42	1,470	*	*
Yuba	67,956	2,378,460	*	*
Other counties	182	6,370	81,199	2,841,965
Totals	237,886	$8,326,010	251,737	$8,810.795

* Included under "Other counties."

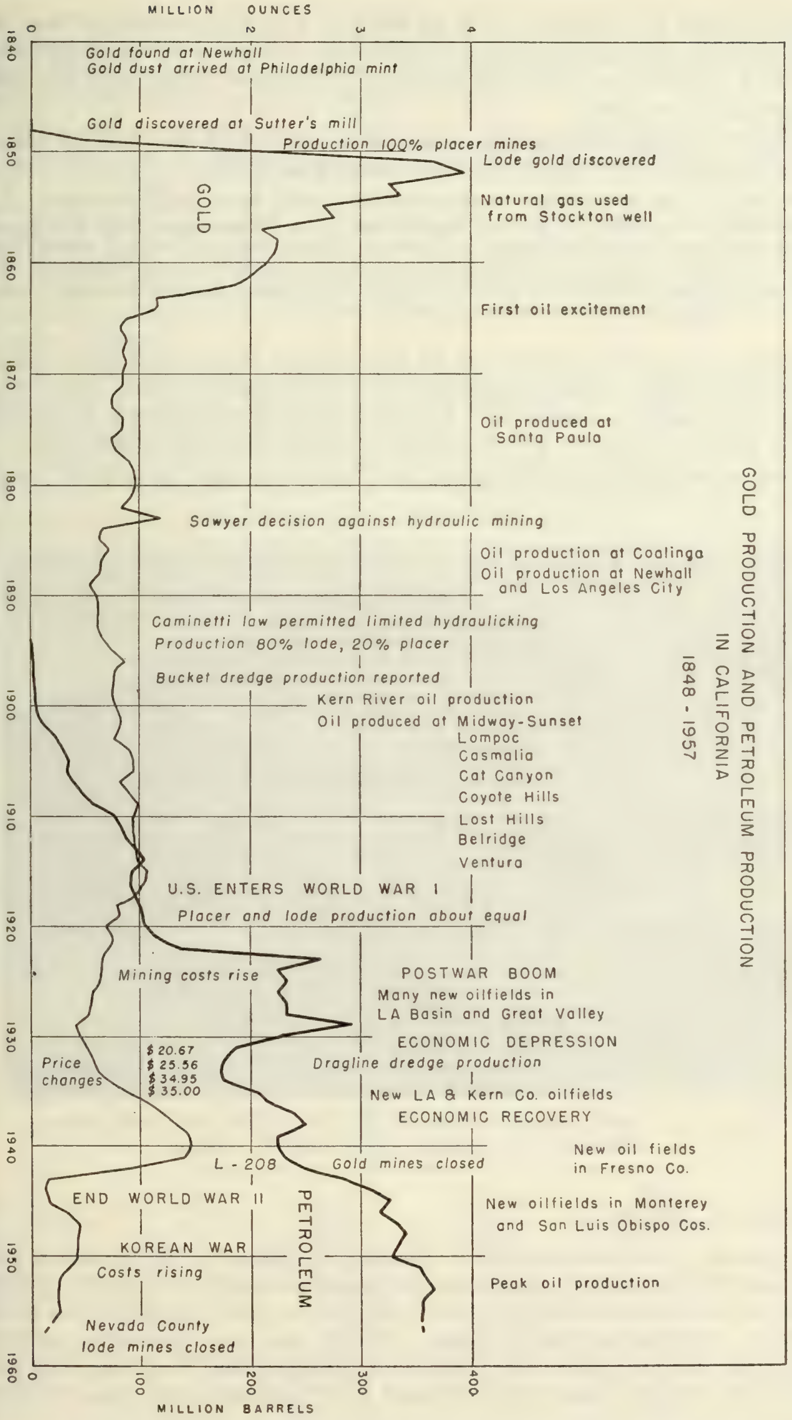


FIGURE 5. Chart showing gold and petroleum production, 1850-1957.

duced 97,689 fine ounces worth $3,419,115. In 1955 production was reported from 82 placer mines and 130 lode mines in 29 counties while in 1954 production was reported from 110 placer mines and 131 lode mines in 29 counties.

The following information was taken from U.S. Bureau of Mines Area Report C-16 * which discusses mining in 1955.

"Gold yield varied slightly compared to 1954, there being little interest in new properties or expansion at current operations. Yuba Consolidated Gold Fields and the Natomas Co., working dredges in Yuba and Sacramento Counties, respectively, were the leading producers; this placer output also resulted in some platinum production. Empire Star Mines Co., Ltd., in the Grass Valley district. Nevada County, and the leading lode-gold producer, ranked third."

Open cut mining continued at the Siskon mine on Dillon Creek, Siskiyou County. This is a gossan gold ore deposit exposed when road cuts were made to ''move in'' diamond drilling equipment. A cyanide plant rated at 100 tons per day began treating ore in October 1953.

The accompanying table gives the California gold output by counties.

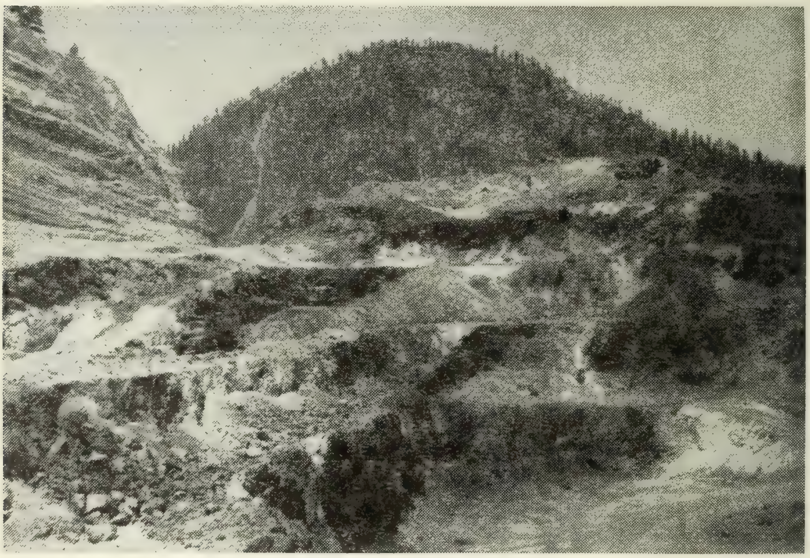


FIGURE 6. Loading gossan ore from Floria pit at Siskon gold mine, Siskiyou County. View northeast. *Photo by J. C. O'Brien.*

Granite (See *Stone*).

Gypsum. California is one of the leading states in the production of gypsum. The quantity and value of gypsum production totaled 1,307,625 short tons worth $3,273,724, and came from four properties in Kern County, two properties in Kings County and one property each in Imperial, Merced, Riverside, San Luis Obispo, and Ventura Counties. The 1955 output showed an increase of 13 percent over that of 1954

* Maurer, R. B., and Wallace, R. E., 1955, The mineral industries of California in 1955; U. S. Bureau of Mines, Area Report C-16.

which amounted to 1,161,502 short tons worth $2,803,862 and came from the same counties. The above figures did not include a considerable tonnage of synthetic gypsum obtained as a by-product from a sea-water magnesia recovery plant in Alameda County.

The gypsum sold as a soil conditioner in agriculture during 1955 totaled 572,511 short tons, compared with 531,678 short tons in 1954.

Iodine. California is the only state in the nation in which iodine is produced. Two companies recovered iodine during 1954 and 1955, from oil well waters at the Dominguez, Long Beach, Inglewood and Seal Beach oil fields. The first three fields are in Los Angeles County. The Seal Beach oil field is partly in Los Angeles County and partly in Orange County.

Iron. The iron ore and concentrates produced in California during 1955 were the largest on record in both quantity and value. The 1955 output totaled 1,776,536 long tons compared with 1,270,292 long tons in 1954 and 1,697,652 in 1953. The 1954 and 1955 production came from one mine in Riverside County and one in San Bernardino County. The shipments of ore and concentrate averaged 54.55 percent iron in 1955. The ore in 1954 averaged 55 percent iron and concentrates averaged 58 percent iron.

The principal production of iron ore in California comes from the captive Eagle Mountain mine in Riverside County which ships to the blast furnaces of the Kaiser Steel Company at Fontana in San Bernardino County. Plans to increase the ore beneficiation facilities were announced during 1955. Iron oxide from the Cave Canyon mine in San Bernardino County was used in the manufacture of ''low-heat'' cement.

Lead. The lead produced in California during 1955 totaled 16,530,000 pounds worth $2,462,970, compared with 5,342,000 pounds worth $731,854 in 1954. The Anaconda Company reopened its mines at Darwin and Shoshone in Inyo County during 1955 which accounted for the large increase in production over 1954.

The accompanying table gives the 1954 and 1955 lead output by counties.

Lead produced in 1954 and 1955, by counties.

County	1954		1955	
	Pounds	Value	Pounds	Value
Amador	2,300	$315	9,500	$1,416
El Dorado	72,300	9,905	45,000	6,705
Inyo	5,253,200	719,688	16,383,900	2,441,201
Mariposa	800	110		
Orange	1,300	178		
Riverside	800	110		
San Bernardino	10,500	1,438	87,700	13,067
Siskiyou	800	110		
Other counties*			3,900	581
Totals	5,342,000	$731,854	16,530,000	$2,462,970

* Other counties include Calaveras, Nevada, and Shasta.

Lime. The lime produced in 1955 totaled 268,009 short tons worth $4,372,789 compared with 212,381 short tons worth $3,387,981 in 1954. The 1955 production was below the high points in quantity and value attained in 1953 by 11 percent and 6 percent respectively. The lime produced in California during 1954 and 1955 came from two properties each in El Dorado and San Bernardino Counties, and one property each in Monterey and Tuolumne Counties. This lime was consumed by the chemical industry, as a refractory in the building industry and in agriculture.

In 1955, 514,818 short tons of limestone worth $917,095 was used in the manufacture of the lime compared with 417,036 short tons worth $1,212,232 in 1954.

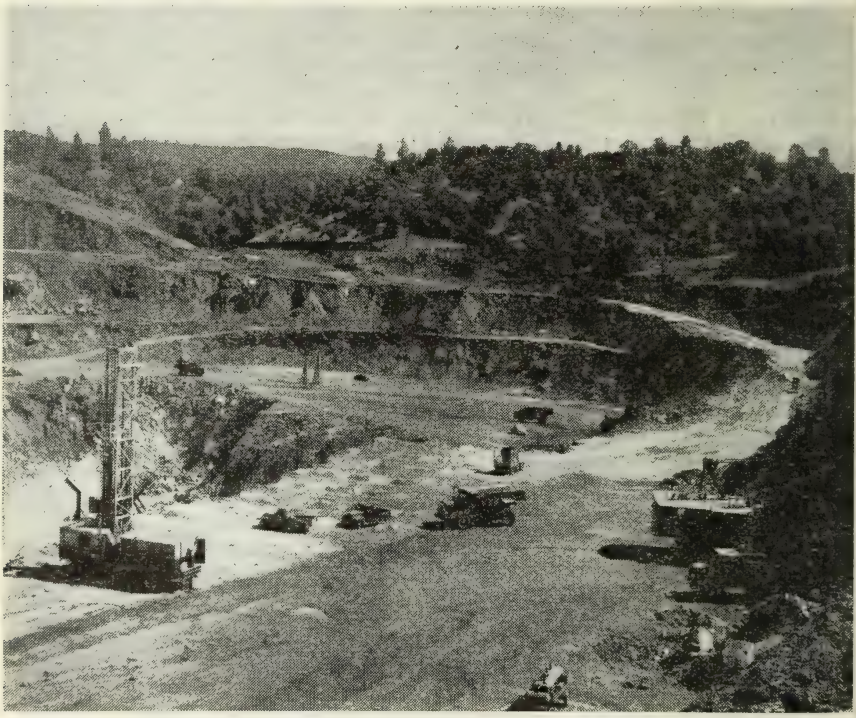


FIGURE 7. View northeast across limestone quarry number 4 of Calaveras Cement Company, Calaveras County. *Photo by D. W. Carlson.*

Limestone (See *Stone*).

Lithium. The brines of Searles Dry Lake, San Bernardino County, California, are the chief source of the state's lithium. The crude material coming from these brines in 1954 and 1955 was a sodium lithium phosphate carrying 20.5 percent Li_2O.

Magnesite. The magnesite shipped in 1954 and 1955 came from the Western mine on Red Mountain, Santa Clara County. The material shipped during both years was consumed in the manufacture of epsom salts.

Magnesium Compounds (From Sea Water and Bitterns). The magnesia (magnesium oxide) produced in California during 1954 and 1955 came from the three plants, one each in Alameda, Monterey, and San Mateo Counties. Magnesium chloride was recovered at a plant in San Diego County. The material from Alameda and San Diego Counties was recovered from salt works bitterns, while that from Monterey and San Mateo Counties was recovered directly from sea water. The 1955 output of magnesium compounds totaled 58,839 short tons worth $3,894,432, compared with 40,969 short tons worth $2,715,689 in 1954.

The plant in San Mateo County produced magnesium oxide, magnesium carbonate, and magnesium hydroxide U. S. P. or technical grades which were used chiefly in pharmaceutical preparations. The material from Alameda and Monterey Counties was used in refractories, oxychloride cements, rayon, insulation, epsom salts, and for other purposes. Insulation manufacturers in Alameda and San Mateo Counties purchased magnesium oxide from the primary producers and converted it into magnesium carbonate for pipe coverings.

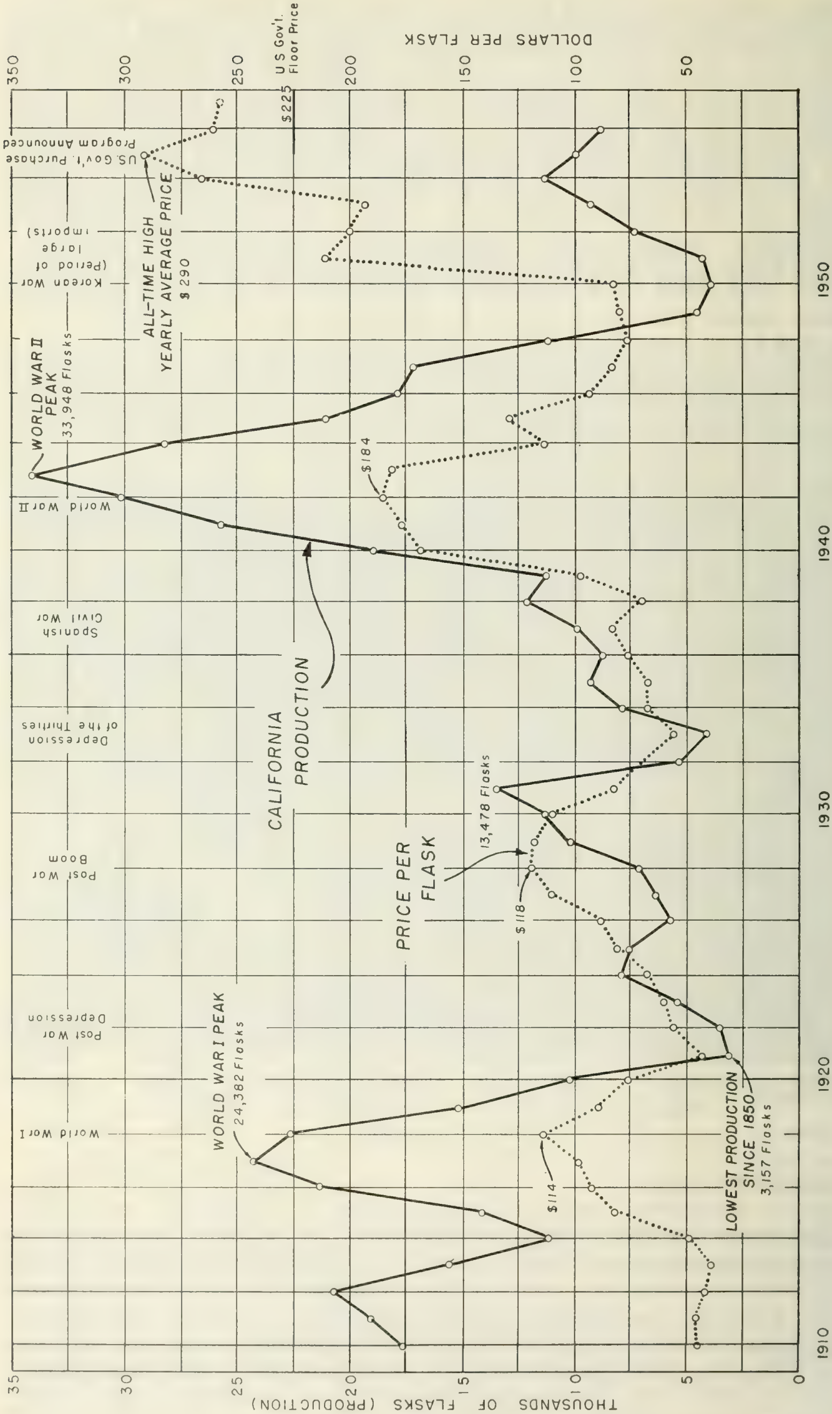
Manganese. An all-time high in the production and value of California manganese ore was reached in 1954. Nearly 75 percent of this output was delivered to the low-grade stockpiles of the U. S. Government. In July 1954 the stockpile at Wenden, Arizona, filled its quota and in November 1954 the stockpile at Deming, New Mexico, filled its quota, whereupon the General Services Administration stopped ore purchases at these depots. At the end of 1954 only the depots at Butte and Philipsburg, Montana, remained open for ore containing less than 40 percent manganese. The railhead, carlot program for ore averaging 40 percent manganese terminates in 1961. Ore production dropped appreciably in 1955 as California producers no longer had a ready market for their low grade products.

Manganese ore produced in 1954 and 1955, by counties.

County	1954		1955	
	Long tons	Value	Long tons	Value
Imperial	*	*	13,998	$546,996
Riverside	8,087	$410,884	5,107	405,172
San Bernardino	6,206	329,848	383	30,165
Trinity	273	31,991	*	*
Other counties	19,137	771,236	3,525	219,474
Totals	33,703	$1,543,959	23,013	$1,201,807

* Included with "Other counties."

Manganese ore and concentrates produced in California during 1955 totaled 6,589 long tons running 35 percent manganese or better worth $563,156 and 16,424 long tons running less than 35 percent manganese worth $638,651, compared with 8,513 long tons running 35 percent manganese or better worth $617,284 and 25,190 long tons running less than 35 percent manganese worth $926,675 in 1954. The manganese mined in 1955 came from mines in Humboldt, Imperial, Inyo, Lake, Mariposa, Mendocino, Plumas, Riverside, San Bernardino, San Joaquin,



CALIFORNIA MERCURY PRODUCTION AND PRICE FLUCTUATIONS, 1910–1957

San Luis Obispo, Siskiyou, Sonoma, Stanislaus and Trinity Counties, while production in 1954 came from mines in Imperial, Inyo, Kern, Lake, Mariposa, Mendocino, Riverside, San Benito, San Bernardino, San Joaquin, San Luis Obispo, Stanislaus and Trinity Counties.

The accompanying table lists the 1954 and 1955 manganese production by counties.

Marl. During 1954, 5,464 short tons of marl valued at $21,965 was produced in California. The 1955 output came from Fresno County and was listed under unapportioned to conceal the figures of the sole producer.

Mercury (Quicksilver). California is the leading mercury producing state and contributed 61 percent of the nation's production in 1954 and 52 percent in 1955. Although mercury production in the United States showed a slight increase during 1955, the quantity of California production dropped 12 percent from the previous year. An important factor was the switch from production to an exploration program at one of the leading mines during the year.

The 1955 output came from 48 operating properties (mines, calcine dumps, tailings piles and prospects) in Fresno, Inyo, Kings, Lake, Marin, Merced, Napa, San Benito, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Sonoma, Stanislaus, and Trinity Counties. Production totaled 9,875 flasks of 76 pounds worth $2,867,206 in 1955, compared with 11,262 flasks worth $2,977,560 in 1954. The 1954 output came from properties in Contra Costa, Del Norte, Fresno, Lake, Merced, Napa, San Benito, San Luis Obispo, Sonoma and Stanislaus Counties.

FIGURE 9. Mining quicksilver ore from dewatered open pit at the Sulphur Bank mine, Lake County. Old tailings pile and mill buildings in background.

Mercury produced in 1954 and 1955, by counties.

County	1954		1955	
	Flasks	Value	Flasks	Value
San Benito	5,255	$1,389,370	*	*
Santa Clara	271	71,650	830	$240,991
Other counties	5,736	1,516,540	9,045	2,626,215
Totals	11,262	$2,977,560	9,875	$2,867,206

* Included with "Other counties" (Fresno, Kings, Lake, Marin, Merced, Napa, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Sonoma, Stanislaus, and Trinity).

The New Idria mine in San Benito County maintained its position as the leading producer of mercury in the state during 1954 and 1955. Other important producers were: Mt. Jackson and Buckman mines in Sonoma County, Abbott mine in Lake County, Emerald Lake mine in San Mateo County, New Almaden and Guadalupe mines in Santa Clara County and the La Libertad mine in San Luis Obispo.

The U. S. Government injected its stabilizing influence into the mercury market during 1954. In March the domestic mercury mines were restored to the list of mineral properties eligible for exploration loans from the Defense Minerals Exploration Administration. In July, the General Services Administration announced a 3½-year fixed price purchase program for mercury, calling for 125,000 flasks of domestically produced metal at $225 per flask. A termination date of December 31, 1957 was placed on this program.

In response to these actions and to industrial demand, the price of mercury proved its volatility during 1954 by rising almost continuously from $187 per flask in January to $330 per flask in October. This is the highest price ever recorded for mercury. With minor fluctuations, the price per flask remained above the $300 mark until the middle of the second quarter of 1955, and closed the year in the $280-$284 range. The annual price averaged $290.35 in 1955, an all-time high.

Mineral Pigments. Mineral pigments manufactured in California during 1954 and 1955 came from plants in Alameda and Amador Counties. The plant in Alameda County produced iron oxide pigments and the plant in Amador County produced a vandyke brown from coal (lignite).

Mineral Water. Water from many springs and artesian wells, bottled and in part artificially carbonated, is classed as mineral water. Health and pleasure resorts are located at many hot springs in California. The water at some of the hot springs is not suitable for drinking but is utilized for bathing. Counties from which mineral waters are bottled and sold are: Butte, Calaveras, Contra Costa, Lake, Los Angeles, Marin, Napa, Orange, Riverside, San Benito, San Bernardino, San Diego, San Francisco, San Luis Obispo, Santa Barbara, Shasta, Siskiyou, Sonoma, and Tehama. No canvass of mineral water producers is made by the U.S. Bureau of Mines.

Molybdenum. Molybdenum concentrates were produced in California as a by-product of tungsten mining. The 1954 and 1955 output came from the Pine Creek mine of the U.S. Vanadium Corporation

near Bishop, Inyo County. Here, the known ore bodies in the contact metamorphic deposit contain molybdenite associated with scheelite. The average grade of the ore milled is about 0.4 percent MoS_2.

Natural Gas. The value of natural gas produced from California wells in 1955 was the highest of any year on record. The quantity of production was the highest since 1951, but was considerably below the peak of 570,954,000 M cubic feet attained in 1948. The 1955 production was 538,178,000 M cubic feet valued at $119,476,000, compared with 507,289,000 M cubic feet worth $104,502,000 in 1954.

Part of the increased gas production may be attributed to the installation of pipeline facilities to previously discovered gas fields with no commercial outlets. The Chowchilla field in Madera County and the Corning field in Tehama County are in this category.

The accompanying table shows the production of natural gas by counties for 1954 and 1955.

Natural gas produced in 1954 and 1955, by counties.

County	1954		1955	
	M cubic feet	Value	M cubic feet	Value
Butte	4,901,552	$1,010,000	6,034,000	$1,339,510
Fresno	34,853,694	7,180,000	36,490,000	8,100,773
Kern	97,399,119	20,064,000	104,638,000	23,229,657
Kings	26,723,945	5,505,000	10,122,000	2,247,019
Los Angeles	90,672,811	18,679,000	106,348,000	23,609,315
Madera	3,143,557	648,000	2,625,000	582,852
Monterey	*	*	8,091,000	1,796,125
Orange	34,719,345	7,152,000	39,731,000	8,820,299
Sacramento	52,676,243	10,851,000	60,467,000	13,423,776
San Joaquin	5,781,610	1,191,000	1,974,000	438,205
San Luis Obispo	1,054,067	217,000	1,947,000	432,206
Santa Barbara	17,625,917	3,631,000	22,637,000	5,025,301
Solano	30,490,330	6,281,000	38,495,000	8,545,989
Tehama	*	*	1,545,000	343,082
Tulare	5,654,560	1,165,000	6,398,000	1,420,465
Ventura	92,622,560	19,080,000	82,113,000	18,229,089
Yolo	2,672,200	550,000	2,227,000	494,315
Other counties	[1]6,297,490	1,298,000	[2]6,296,000	1,397,529
Totals	507,289,000	$104,502,000	538,178,000	$119,475,516

* Included with "Other counties."
[1] Includes Alameda, Colusa, Contra Costa, Glenn, Humboldt, Monterey, San Benito, Sutter, and Tehama Counties.
[2] Includes Alameda, Colusa, Contra Costa, Glenn, Humboldt, San Benito, San Bernardino, San Mateo, Santa Clara, Sonoma, and Sutter Counties.

California is the second largest natural gas-consuming state in the country. Consumption in California during 1954 was 933,934 million cubic feet, an increase of 8.3 percent over the previous year, and 84 percent over production. This tremendous local demand has been supplied by increased imports via pipelines from the gas fields of New Mexico and west Texas.

Natural Gas Liquids. Natural gas liquids reached all time highs in quantity and value of reported production during 1954, but the 1955 output and value showed a slight decline from these high points.

The 1955 output of natural gas liquids totaled 30,727,000 barrels worth $108,382,000, compared with 31,413,000 barrels worth $111,555,-000 in 1954.

The table gives the 1954 and 1955 output of natural gas liquids by counties:

Natural gas liquids produced in 1954 and 1955, by counties.

County	1954		1955	
	Barrels	Value	Barrels	Value
Fresno	2,934,000	$9,518,696	2,918,000	$10,123,000
Kern	8,809,000	30,508,600	8,882,000	30,492,000
Kings and San Luis Obispo	1,889,000	5,838,214	914,000	3,116,000
Los Angeles	7,471,000	28,761,070	8,092,000	31,022,000
Orange	4,406,000	15,996,492	3,204,000	12,663.000
Santa Barbara	1,430,000	5,059,219	1,475,000	5,129,000
Ventura	4,474,000	15,872,709	5,242,000	15,837,000
Totals	31,413,000	$111,555,000	30,727,000	$108,382,000

Of the 1955 output of liquefied petroleum gases, 22,134,000 barrels of natural gasoline and condensates worth $89,003,000 and 8,593,000 barrels of liquefied petroleum gases worth $19,379,000 compared with 21,980,000 barrels of natural gasoline and condensates worth $89,293,000 and 9,433,000 barrels of liquefied petroleum gases worth $22,262,000 in 1954.

Peat. Peat deposits are widespread in California, but only in four areas are the deposits known to be of suitable quality, size, and location to be of present commercial value. These areas, from which substantial amounts of peat have been mined and then processed, are the Sacramento-San Joaquin Delta area, Orange County, Modoc County and Santa Cruz County.

In the United States peat is used mostly as a soil conditioner and in mixed fertilizers. Very small amounts are used as mull or litter material for domestic animals, as packing material, and in chemical applications such as filtering and tanning.

The peat produced in California during 1954 and 1955 came from properties in Contra Costa, Modoc and Orange Counties. All was sold as soil conditioner. The peat from Contra Costa County was reed or sedge peat, that from Modoc County was peat moss and that from Orange County was humus.

Perlite. Crude perlite produced in California comes from properties in Inyo, Napa, and San Bernardino Counties. In 1955 the crude perlite produced in the state totaled 15,653 short tons valued at $125,113 compared with 14,811 short tons worth $103,148 in 1954.

Expanded perlite produced and shipped in California in 1955 totaled 25,610 short tons worth $1,349,947 compared with 24,794 short tons worth $1,079,775 during the previous year. During 1955 six expanding plants were operating in Los Angeles County and one each in Fresno, Marin, Napa, Riverside, San Diego and San Mateo Counties. The plant in Riverside County did not report production in 1954 and the plant in San Mateo started operation in 1955. During 1954 a small production was reported by a plant in San Bernardino County. All other plants reporting in 1954 operated also in 1955.

Petroleum. California is the second largest petroleum producing state in the nation. During 1955 the production of crude oil was 354,-737,000 barrels worth $886,820,000, compared with 355,865,000 barrels worth $907,460,000 in 1954. The California petroleum output for 1954 and 1955 by counties is tabulated as follows:

Petroleum produced in 1954 and 1955, by counties.

County	1954		1955	
	Barrels	Value	Barrels	Value
Fresno	34,643,000	$98,556,000	36,292,000	$91,136,898
Kern	91,110,000	225,152,000	94,455,000	233,512,222
Kings	2,774,000	8,788,000	2,668,000	8,123,721
Los Angeles	92,972,000	248,160,000	91,344,000	237,106,571
Monterey	11,213,000	13,587,000	10,972,000	16,425,890
Orange	37,824,000	93,363,000	41,754,000	103,345,839
San Luis Obispo	3,185,000	9,488,000	2,803,000	8,533,667
Santa Barbara	33,342,000	77,492,000	30,396,000	69,815,444
Ventura	48,714,000	132,678,000	43,914,000	118,492,977
Other counties*	[a]88,000	196,000	[b]139,000	326,771
Totals	355,865,000	$907,460,000	354,737,000	$886,820,000

[a] Includes Humboldt, San Benito, San Bernardino, Santa Clara, Sonoma, and Tulare Counties.
[b] Includes San Benito, San Bernardino, San Mateo, Santa Clara, Sonoma, and Tulare Counties.

Platinum. California is the leading state of the nation in the production of platinum group metals. Crude platinum was produced in California during 1954 and 1955 as a byproduct of gold dredging along the American River in Sacramento County and along the Yuba River in Yuba County.

Potash. California is the second ranking state in the production of potassium salts. Potassium salts were produced in California during 1954 and 1955 from the brines of Searles Dry Lake, San Bernardino County, by the American Potash and Chemical Company.

Pumice, Pumicite and Volcanic Cinders. California ranks second among the states in the production of pumice, pumicite and volcanic cinders. During 1955 a total of 797,306 short tons worth $1,099,459 was produced, compared with 566,664 short tons worth $651,638 in 1954. In 1955 pumice and pumicite amounted to 88,825 short tons worth $416,309, while volcanic cinders amounted to 708,481 short tons worth $683,150. In 1954 pumice and pumicite amounted to 70,964 tons worth $421,208 while volcanic cinders amounted to 495,700 tons worth $230,430.

In 1955 the pumice came from four properties in Siskiyou County; two properties in Inyo and two in Modoc Counties; and one property in Amador, Calaveras, Imperial, Kern, Merced and San Bernardino Counties. Pumicite was mined from two properties in Madera County and one in Inyo County. Volcanic cinders were mined from three properties in Lassen and three in Siskiyou Counties; two properties in Inyo, Modoc and San Bernardino Counties; and one property in Lake County and one in Shasta County.

Pyrite. Pyrite produced in California during 1954 and 1955 came from the Hornet mine at Matheson, Shasta County. This underground mine has been the chief source of the state's pyrite for many years. Late

Sand and gravel produced in 1954 and 1955, by counties.

County	1954		1955	
	Short tons	Value	Short tons	Value
Alameda (ms)	4,165,508	$4,504,811	7,321,999	$7,955,858
Amador (gs)	39,286	17,244	*	*
Butte	849,182	1,030,391	672,499	779,418
Colusa	*	*	344,383	314,123
Contra Costa (ms)	516,912	507,978	117,649	126,553
Del Norte	730,315	393,248	305,666	294,802
El Dorado	84,727	69,756	172,689	154,711
Fresno	1,245,458	1,213,555	992,151	1,053,145
Glenn	485,929	289,594	368,273	279,379
Humboldt	702,624	604,954	715,075	570,611
Imperial (fs)	922,857	749,286	482,658	331,739
Inyo	92,452	65,419	216,068	178,618
Kern (bs)	659,508	797,214	923,785	1,205,055
Lake	181,353	130,869	*	*
Lassen	106,020	95,008	349,036	210,945
Los Angeles (bs, ms)	25,359,979	23,010,654	18,792,178	17,564,223
Madera	*	*	96,315	61,198
Mariposa	81,996	86,167	77,332	146,258
Mendocino	525,645	630,348	303,596	355,261
Merced	1,247,551	856,870	951,617	1,057,909
Modoc	447,324	310,682	216,071	182,685
Mono	*	*	105,611	88,740
Monterey (bs, fs, gs, ms)	1,073,455	2,381,204	631,173	1,411,625
Napa	19,723	22,708	167,115	120,055
Nevada	90,416	117,816	39,140	35,773
Orange (ms)	3,681,772	3,424,748	4,585,285	3,844,108
Placer	130,114	106,082	149,149	161,014
Plumas	*	*	201,595	122,263
Riverside (gs)	829,918	1,302,672	895,236	1,337,400
Sacramento	5,244,901	4,979,181	3,549,040	3,844,078
San Benito	*	*	178,845	95,089
San Bernardino	4,287,413	3,666,511	2,657,200	2,731,792
San Diego (bs, fs, gs, ms)	4,079,276	4,718,778	2,793,511	4,557,591
San Joaquin	1,709,372	1,650,806	1,998,700	1,747,066
San Luis Obispo	631,903	386,996	573,954	352,602
San Mateo	*	*	283,037	179,554
Santa Barbara	837,923	667,188	585,366	844,420
Santa Clara	557,974	525,119	998,667	1,059,875
Santa Cruz	763,318	726,470	706,525	672,847
Shasta	639,622	582,836	612,677	581,396
Sierra	*	*	37,925	60,764
Siskiyou	181,903	168,693	193,436	163,197
Solano	*	*	453,229	282,117
Sonoma	*	*	1,380,124	1,366,846
Stanislaus	487,433	594,631	506,147	456,038
Sutter	*	*	106,209	75,556
Tehama	358,804	324,895	410,443	374,674
Trinity	70,873	81,639	68,435	55,351
Tuolumne	*	*	68,951	149,377
Ventura (ms)	1,529,034	1,493,769	4,021,006	3,764,249
Yolo	1,124,153	932,615	878,698	806,218
Yuba (bs)	*	*	431,625	513,202
Other counties	[a]3,750,686	3,921,173	[b]1,491,056	2,142,992
Totals	70,524,612	$68,138,578	64,878,648	$66,820,360

* Included with "Other counties."
[a] Other counties include: Alpine, Calaveras, Colusa, Kings, Madera, Marin, Mono, Plumas, San Benito, San Mateo, Sierra, Solano, Sonoma, Sutter, Tulare, Tuolumne, and Yuba.
[b] Other counties include: Alpine, Amador (gs), Calaveras, Kings, Lake, Marin, San Francisco, and Tulare.
(gs)—glass sand.
(ms)—molding sand.
(fs)—filter sand.
(bs)—blast sand.

in 1955 mining at this property was converted to an open pit operation by stripping the overburden from part of the pyrite orebody.

Quicksilver (see Mercury).

Rare Earth Minerals. Rare earth minerals were produced commercially for the first time in California during 1952 from a property near Mountain Pass in San Bernardino County by the Molybdenum Corporation of America. The mineral found is bastnasite, a fluocarbonate of cerium and lanthanum which is mined in an open cut. Mining continued through 1955 and the ore was concentrated by flotation. Mining was hampered during 1955 by the limited market for the contained cerium metals.

Salt. California is one of the principal salt producing states. Most of the production is made by solar evaporation of sea water on the shores of southern San Francisco Bay. The quantity and value of the 1955 salt crop in California was the largest of any year on record and totaled 1,314,835 short tons worth $6,751,420. The 1954 output of salt was 1,185,844 short tons worth $6,126,194. Both the 1954 and 1955 salt production came from four properties in Alameda County, three in San Bernardino County, and one each in Kern, Monterey, Orange, and San Diego Counties. All counties with the exception of San Bernardino produced salt by solar evaporation.

Sand and Gravel. California leads all states in the production of sand and gravel. The California output of sand and gravel in 1954 was the largest in both quantity and value of any year on record. Production dipped slightly in 1955 owing to a trucking strike in the Los Angeles area.

Since a high percentage of sand and gravel is used in building and related construction projects, the largest production was made near large metropolitan centers. The combined value of production from Los Angeles and Alameda Counties constituted 40 percent of the state's total.

The California production of sand and gravel for 1955 totaled 64,-878,648 short tons worth $66,820,360 compared with 70,524,612 short tons worth $68,138,578 in 1954. In 1955 all the counties but San Francisco contributed to the state's total. The accompanying table lists the 1954 and 1955 sand and gravel output by counties.

Silica. Beginning in 1955, quartz and quartzite was included with crushed stone and silica sand with sand and gravel. In 1954 ground silica sand was produced from single properties in Monterey and San Diego Counties.

During 1954, exploration and development work was begun in the foothills of the Sierra Nevada on large deposits of loosely consolidated, quartz-rich sandstone of the upper part of the Ione formation of Eocene age. During 1955 plants were erected at two of these localities to separate the sand for use in the manufacture of glass. The sandstone contains 25 to 40 percent high duty clay which will be separated and recovered for use in ceramics.

Silver. The silver produced in California is as a byproduct from the ores of gold, copper, lead and zinc. The California output of silver in 1955 was 954,181 fine ounces worth $863,582 as compared with 309,575 fine ounces worth $280,181 in 1954. In both 1954 and 1955 the lead zinc mines of the Darwin and Shoshone districts of Inyo County

were the largest producers of silver followed by a gold mine in the Happy Camp district of Siskiyou County.

The accompanying table gives the 1954 and 1955 silver output of California by counties.

Silver produced in 1954 and 1955, by counties.

County	1954		1955	
	Fine ounces	Value	Fine ounces	Value
Amador	3,292	$2,979	8,967	$8,107
Butte	26	24	11	10
Calaveras	146	132	64	58
Del Norte	----------	----------	1	1
El Dorado	5,090	4,607	3,238	2,931
Fresno	27	24	31	28
Imperial	11	10	*	*
Inyo	234,254	212,012	838,412	758,805
Kern	14,065	12,730	29,262	26,484
Los Angeles	29	26	92	83
Madera	928	840	3	3
Mariposa	227	205	164	148
Mono	1,953	1,768	*	*
Orange	632	572	----------	----------
Nevada	15,733	14,239	14,724	13,326
Placer	46	42	21	19
Plumas	307	278	79	71
Riverside	42	38	*	*
Sacramento	2,620	2,371	2,444	2,212
San Bernardino	3,832	3,468	2,649	2,397
Shasta	*	*	479	434
Sierra	2,612	2,364	3,649	3,303
Siskiyou	18,960	17,160	43,518	39,386
Trinity	652	590	758	686
Tuolumne	6	5	*	*
Yuba	4,050	3,665	*	*
Other counties	35 [a]	32	5,615 [b]	5,090
Totals	309,575	$280,181	954,181	$863,582

* Included under "Other counties."
[a] Includes San Diego and Shasta Counties.
[b] Includes Imperial, Mono, Riverside, Tuolumne, and Yuba Counties.

Slate. Slate was mined and shipped in California during 1954 and 1955 from two quarries in El Dorado County. The material was used as flagstone, roofing granules, and the slate flour as a filler.

Sodium Salts. California is the largest producer of natural sodium carbonates and sulfates. These salines are extracted from the brines of the desert dry lakes in the southeastern part of the state.

The value of the 1955 output of sodium carbonate in California was the largest on record and came from two properties on Searles Lake, San Bernardino County, one property near Muroc Dry Lake, Kern County, and one property on Owens Lake, Inyo County. The 1954 output of those materials came from two properties in San Bernardino County and one in Inyo County.

The sodium sulfate or salt cake produced in California during 1955 was also the largest on record in both quantity and value. Production was made from two properties in San Bernardino County (one on Dale Dry Lake and the other on Searles Dry Lake), and a property near

Muroc Dry Lake, Kern County. The 1954 sodium sulfate came from the two properties in San Bernardino County.

Stone. The total of all stone produced in California during 1955 was 24,708,321 short tons worth $37,164,384 of which 514,818 short tons worth $917,095 was limestone used in the manufacture of lime and 10,462,734 short tons worth $15,514,339 was limestone used in the manufacture of cement. The 1954 stone output was 23,303,756 short tons worth $37,541,114 of which 417,036 short tons worth $1,212,232 was limestone used in the manufacture of lime and 9,150,155 short tons worth $16,017,315 was limestone used in the manufacture of cement. The accompanying table reports the stone output by counties for 1954 and 1955 (not including the limestone used in the manufacture of lime or cement). Included in the figures for stone are such special products as dimension granite, industrial limestone, and other dimension stones.

The dimension granite quarried in California during 1955 totaled 30,308 cubic feet worth $209,802 and came from quarries in Lassen, Madera, Riverside, San Diego and Tulare Counties, compared with 40,896 cubic feet worth $218,628 during 1954 from quarries in Fresno, Humboldt, Lassen, Madera, Riverside, and San Diego Counties.

Stone (crushed) produced in 1954 and 1955, by counties.[c]

County	1954		1955	
	Short tons	Value	Short tons	Value
Alameda	1,230,163	$939,021	1,313,058	$1,018,134
Amador	7,374	15,858	*	*
Butte	57,669	23,495	*	*
Contra Costa	851,581	1,195,252	1,597,564	2,153,561
Del Norte	146,509	620,561	75,750	77,100
El Dorado	388,054	725,459	204,039	621,826
Fresno	504,408	510,492	304,489	277,039
Humboldt	38,941	90,845	21,550	17,475
Kern	106,535	259,873	188,119	518,237
Los Angeles	3,795,444	4,616,995	2,424,990	2,910,651
Monterey	101,013	240,139	61,143	267,621
Napa	*	*	722,549	998,170
Riverside	*	*	288,340	548,896
San Bernardino	312,050	1,562,239	591,268	2,487,763
San Diego	398,526	743,987	164,714	397,803
San Mateo	*	*	1,267,526	1,625,897
Santa Clara	1,161,742	717,783	1,391,105	896,857
Siskiyou	72,000	144,905	61,633	159,694
Solano	*	*	143,030	213,759
Sonoma	*	*	235,041	375,499
Tehama	*	*	6,148	29,314
Tuolumne	67,158	371,686	120,261	461,669
Ventura	*	*	198,856	428,895
Other counties	4,497,398	7,532,977	2,349,596	4,247,090
Total	13,736,565	$20,311,567	13,730,769	$20,732,950

* Included with "Other counties."

[a] Includes Calaveras, Imperial, Kings, Lake, Lassen, Madera, Marin, Mendocino, Modoc, Napa, Orange, Placer. Plumas, Riverside, San Benito, San Luis Obispo, San Mateo, Santa Barbara, Santa Cruz, Shasta, Solano, Sonoma, Tehama, Trinity, Tulare, and Ventura Counties.

[b] Includes Amador, Buutte, Imperial, Inyo, Kings, Lake, Lassen, Madera, Marin, Mendocino, Orange, Placer, Plumas, San Benito, San Francisco, San Luis Obispo, Santa Barbara, Santa Cruz, Shasta, Trinity, and Tulare Counties.

[c] Not including limestone used in lime and cement.

FIGURE 10. View showing steeply dipping beds of Franciscan sandstone and interbedded shale with new crushing unit in left middle ground. Blake Brothers quarry, Contra Costa County.

The industrial limestone and marble produced in California in 1955 (exclusive of the quantity used in the manufacture of cement and lime) totaled 1,336,781 short tons worth $4,643,487. Industrial limestone includes material used as a flux in refractories, in the manufacture of sugar, in paint whiting, in asphalt, in agriculture, as a poultry grit and stock food, as roofing granules, in stucco dash, in terrazzo and for other uses. The 1955 production came from properties in El Dorado, Monterey, Riverside, San Benito, San Bernardino, San Luis Obispo, San Mateo, Santa Clara, Santa Cruz, Shasta, Tuolumne and Ventura Counties. Part of the material from San Mateo and Santa Clara Counties and that from Ventura County was shells. The limestone produced in 1954 totaled 1,311,314 short tons worth $4,271,102 and came from the same counties reporting in 1955, plus Shasta County.

Other dimension stone produced in 1955 in California totaled 21,234 short tons worth $341,597, compared with 7,305 short tons worth $61,278 in 1954. The latter material included rhyolite tuff from El Dorado County, volcanic rock from Kern County, mica schist and silicified diatomite from Los Angeles County, indurated shale from Monterey County, rhyolite from San Bernardino County, and Santa Clara County, and banded rhyolite from Sonoma County.

Strontium. During 1955 a small amount of celestite (strontium sulfate) was produced and shipped from a property in the Cady Mountains, San Bernardino County. The production in 1954 came from the Fish Creek Mountains, Imperial County.

Sulfur. During 1955 sulfur ore was shipped from the Leviathan mine in Alpine County and one mine in Inyo County totaling 199,599

long tons, compared with 185,085 long tons from the same mines in 1954. The 1955 output of sulfur was the largest on record in California. The relatively low grade sulfur ore was manufactured into sulfuric acid at Weed Heights, Nevada, where the acid was used to leach a low grade copper carbonate deposit.

By-product sulfur (brimstone and hydrogen sulfide) from petroleum refineries was produced in California during 1955 totaling 136,792 long tons of contained sulfur worth $3,829,049, compared with 96,960 long tons of contained sulfur worth $2,963,410 in 1954. The brimstone was recovered from three plants in Los Angeles County and one plant each in Contra Costa and San Luis Obispo Counties. The hydrogen sulfide was recovered from three plants in Los Angeles County and two in Contra Costa County. The refineries which recovered brimstone did not recover hydrogen sulfide.

Talc, Pyrophyllite and Soapstone. The talc, pyrophyllite and soapstone produced in California during 1955 totaled 166,551 short tons worth $1,552,783, compared with 133,474 short tons worth $1,211,201 in 1954.

The 1955 quantity and value of crude talc, soapstone and pyrophyllite was the largest of any year on record. The accompanying table reports the 1954 and 1955 talc, pyrophyllite and soapstone output by counties.

Talc, pyrophyllite and soapstone produced in 1954 and 1955, by counties.

County	1954		1955	
	Tons	Value	Tons	Value
Inyo	48,481	$484,106	64,102	$686,209
San Bernardino	55,635	642,524	57,672	664,245
Other counties	[a]29,358	84,571	[b]44,777	202,329
Totals	133,474	$1,211,201	166,551	$1,552,783

[a] Includes El Dorado, Los Angeles, Mono, Riverside, and San Deigo Counties.
[b] Includes El Dorado, Los Angeles, Mono, Placer, and San Diego Counties.

The production from Inyo County and most of the production from San Bernardino County was high grade talc. Pyrophyllite came from Mono, Plumas, San Bernardino and San Diego Counties and the soapstone from El Dorado, Los Angeles and Riverside Counties.

During 1955, 69,910 short tons of California's talc was used in ceramics; 41,129 tons of talc, soapstone and pyrophyllite were used in insecticides, and 28,428 short tons of talc and pyrophyllite were used in paint. The remaining production was used in the manufacture of rubber, paper, toilet preparations, stucco, plaster, roofing, rice polishing, textiles and asphalt filler. In 1954 the ceramic industry used 61,800 short tons, the insecticides industry 24,922 short tons, and the paint industry, 25,922 short tons.

Titanium. No ilmenite was reported mined during 1954 or 1955. However, shipments were reported during both years from a stockpile of ilmenite sand mined several years ago at Hermosa Beach, Los Angeles County.

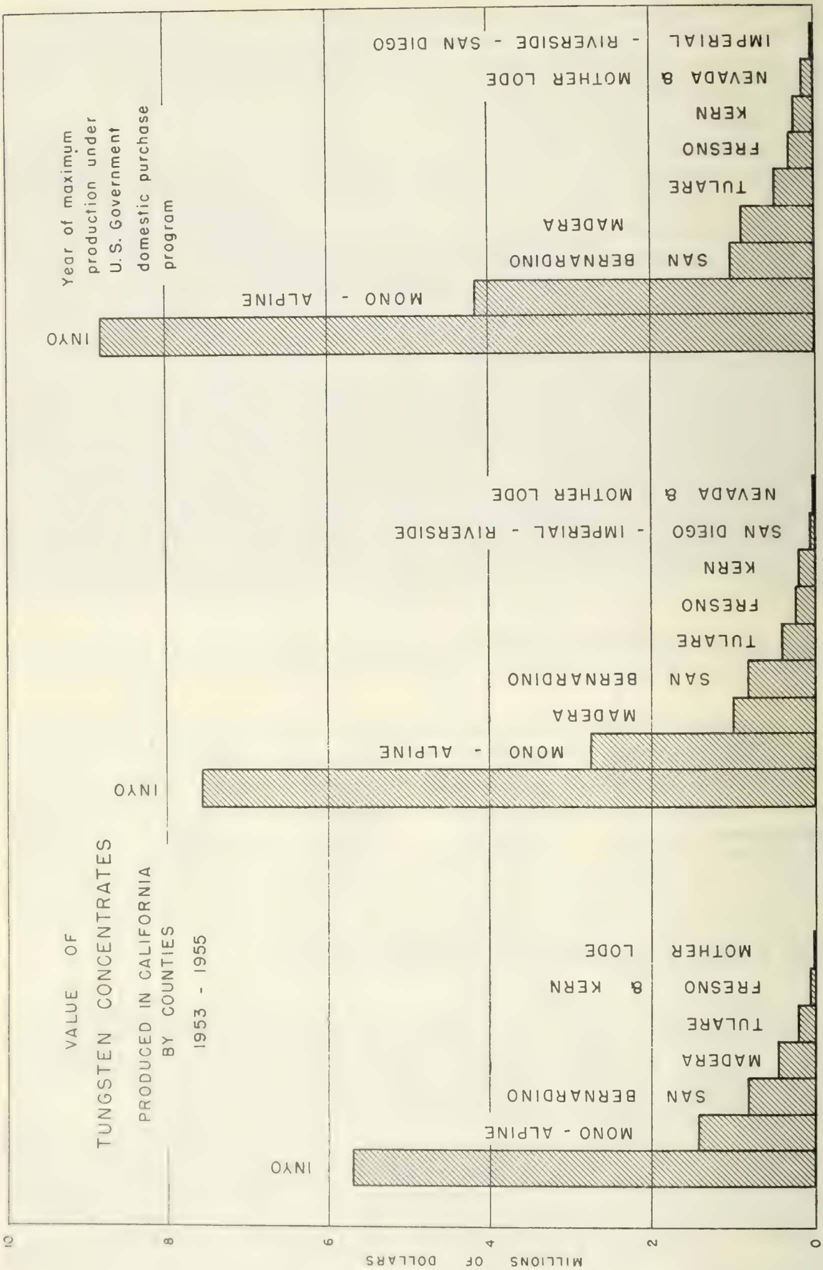


FIGURE 11. Chart showing value of tungsten concentrates by counties, 1953-55.

Tungsten ore and concentrates produced in 1954 and 1955, by counties.

County	1954		1955	
	Short ton units WO_3	Value	Short ton units WO_3	Value
Fresno	4,012	$251,472	5,407	$333,071
Inyo	120,558	7,556,575	*	*
Kern	3,819	239,375	4,744	292,230
Mono	43,546	2,729,463	*	*
San Bernardino	*	*	15,464	1,031,985
Tulare	6,639	416,133	7,708	474,813
Other counties	[a]32,169	2,016,353	[b]330,072	14,068,825
Totals	210,743	$13,209,371	363,395	$16,200,924

* Included with 'Other Counties.'
[a] Includes Alpine, Amador, Calaveras, El Dorado, Imperial, Lassen, Madera, Mariposa, Nevada, Riverside, San Bernardino, San Diego and Tuolumne Counties.
[b] Includes Alpine, El Dorado, Imperial, Inyo, Madera, Marin, Mariposa, Mono, Nevada, Riverside, San Diego, Shasta and Tuolumne Counties.

Tungsten. Tungsten concentrates (60 percent WO_3 basis) totaling 4,383 short tons and valued at $16,200,924 were shipped in 1955, compared with 3,512 short tons valued at $13,209,371 in 1954.

The accompanying table lists the 1954 and 1955 tungsten production by counties.

A quotation from Maurer * presents an outline of tungsten activities during 1955.

"It is estimated that production of tungsten concentrates derived from ore mined in California rose in 1955 surpassing the high of 1954 and placing California second to Nevada in this category. Shipments of tungsten concentrates by California mills and buyers, however, led the Nation. The combined outputs of Union Carbide Nuclear Co. (formerly U. S. Vanadium Co.), Inyo County; Wah Chang Mining Corp. (formerly Black Rock Mining Corp.), Mono County; and Surcease Mining Co., San Bernardino County, was a large factor in the State's tungsten production; but the aggregate yield from numerous smaller mines accounted for about 25 percent of the California total. Many operators were attempting to increase production so as to take full advantage of the support price when it appeared that the Government Purchase Program goal of 3 million short tons units of WO_3 might be reached in 1956. Production of scheelite by Idaho-Maryland Mines Corp., in the Grass Valley gold district, Nevada County, was an interesting development in 1955."

Uranium. Public interest in prospecting for uranium which has been stimulated during recent years reached a high point during 1954 and 1955. The first truckload shipment of uranium ore was made from a property in San Bernardino County on July 14, 1954. On July 31, 1954 the first carload shipment of uranium ore was made from the Miracle mine in Kern County.

A relatively small tonnage of ore was shipped also during 1955. Exploration work was reported in Lassen, Plumas, Calaveras, Kern, Inyo and Monterey Counties. An operator of uranium claims in Kern County adapted a mill near Mojave to the treatment of uranium ore on an experimental basis.

* Maurer, R. B., and Wallace, R. E., 1955, The mineral industries of California in 1955: U. S. Bur. Mines, Area Report C-16.

Wollastonite. A small quantity of wollastonite was mined from properties near Blythe, Riverside County during 1954 and 1955, and was sold as ornamental stone.

Zinc. Zinc ores are currently produced chiefly with the lead-silver ores from the desert mines of southeastern California. Zinc ores are produced also from the copper-zinc ores of mines in the Sierran foothill and Shasta copper belts located in the east central and northern parts of the state, respectively. The total zinc produced in the state in 1955 was 13,672,000 pounds worth $1,681,656 compared with 2,830,000 pounds worth $305,640 in 1954. The accompanying table reports the county distribution of zinc for 1954 and 1955.

Zinc produced in 1954 and 1955, by counties.

County	1954		1955	
	Pounds	Value	Pounds	Value
El Dorado	43,300	$4,676	19,100	$2,349
Inyo	2,771,100	299,279	13,594,500	1,672,124
Madera	100	11	------	------
Mariposa	600	65	100	12
Orange	7,900	853	------	------
San Bernardino	5,800	626	46,600	5,732
Shasta	------	------	8,200	1,009
Sierra	1,200	130	1,400	172
Other counties	------	------	2,100	258
Totals	2,830,000	$305,640	13,672,000	$1,681,656

DIRECTORY OF MINERAL PRODUCERS IN CALIFORNIA DURING 1956

(With addresses corrected to 1957)

California Division of Mines, Ferry Building, San Francisco

(Producers of natural gas and petroleum may be found in the Summary of Operations, California Oil Fields, July-Dec. 1956, vol. 42, no. 2, of the State Division of Oil and Gas)

Asbestos

Mine	Operator	Address	Location
Inyo County:			
Tin Mountain (amphibole)	Huntley Industrial Minerals, Inc.	P.O. Box 305, Bishop	Lone Pine
Napa County:			
Phoenix (chrysotile)	Tabor Mining Co.	1023 Woodside Dr., Napa	Monticello
Placer County:			
Noon Day (tremolite)	Zimdars & Delmue	365 Foresthill Ave., Auburn	Iowa Hill

Barite

Operator	Address	Location
Inyo County:		
Charles F. Ristine	Inyokern	Inyokern
Nevada County:		
Baroid Division, National Lead Co.	P.O. Box 1675, Houston, Texas	Washington
Tulare County:		
Macco Corp., Drilling Fluids Division	14409 S. Paramount Blvd., Paramount	Linnie

Borates

Operator	Address	Location
Inyo County:		
Pacific Coast Borax Division, U. S. Borax & Chemical Corp.	P.O. Box 9128, Sta. S, Los Angeles 5	Shoshone
Kern County:		
Pacific Coast Borax Division, U. S. Borax & Chemical Corp.	P.O. Box 9128, Sta. S, Los Angeles 5	Boron
San Bernardino County:		
American Potash and Chemical Corp.	3030 W. Sixth St., Los Angeles 54	Trona
West End Chemical Division, Stauffer Chemical Co.	1956 Webster St., Oakland 12	Westend

Bromine

Operator	Address	Location
Alameda County:		
Westvaco Mineral Products Division, Food Machinery and Chemical Corp.	405 Lexington Ave., New York, N. Y.	Newark
San Bernardino County:		
American Potash and Chemical Co.	3030 W. Sixth St., Los Angeles 54	Trona

Calcium Chloride

Operator	Address	Location
San Bernardino County:		
California Salt Co.	2436 Hunter St., Los Angeles 21	Amboy
Hill Brothers Chemical Co.	2159 Bay St., Los Angeles 21	Amboy
National Chloride Company of America	Rm. 625, 433 S. Spring St., Los Angeles 13	Amboy

Carbon Dioxide

Operator	Address	Location
Mendocino County:		
Caldri Ice Corp.	Old River Rd., Hopland	Hopland

Cement

Operator	Address	Location
Calaveras County:		
Calaveras Cement Co.	315 Montgomery St., San Francisco 6	San Andreas
Kern County:		
Monolith Portland Cement Co.	Box 65947 Glassell Sta., Los Angeles 65	Monolith
California Portland Cement Co.	612 S. Flower St., Los Angeles 17	Mojave
Los Angeles:		
Blue Diamond Corp.	1650 S. Alameda St., Los Angeles 54	Los Angeles
Riverside County:		
Riverside Cement Co.	621 S. Hope St., Los Angeles 17	Crestmore
San Benito County:		
Ideal Cement Co.	620 Denver Nat. Bank Bldg., Denver 2, Colo	San Juan Bautista
San Bernardino County:		
California Portland Cement Co.	612 S. Flower St., Los Angeles 17	Colton
Riverside Cement Co.	621 S. Hope St., Los Angeles 17	Oro Grande
Southwestern Portland Cement Co.	1034 Wilshire Blvd., Los Angeles 17	Victorville
San Mateo County:		
Ideal Cement Co.	620 Denver Nat. Bank Bldg., Denver 2, Colo	Redwood City
Santa Clara County:		
Permanente Cement Co.	Permanente	Permanente
Santa Cruz County:		
Pacific Cement & Aggregates Inc.	400 Alabama St., San Francisco 10	Davenport

Chromite

Mine	Operator	Address	Location
Butte County:			
Lambert	Castella Mining & Milling Co.	24 California St., San Francisco	Magalia
Del Norte County:			
Azalea	L. C. Brayton	Crescent City	Crescent City
Azalea	W. O. Busch	Rt. 1, Box 846, Cave Junction, Ore.	Crescent City
Azalea	Larry Lee & Louis Lively	Box 204, Crescent City	Crescent City
Azalea	James L. Perry & H. D. Miller	P.O. Box 32, Cave Junction, Ore.	Crescent City
Bar-Rick & Buckskin	Ben Baker & R. Costello	Crescent City	Mill Creek
Big Dipper	Victor Bagg	806 SE. Eighth St., Grants Pass, Ore.	Gordon Mountain
Big Lift, Copper Creek	Simonson Logging Co.	Box 199, Smith River	Smith River
Black Rock No. 3	M. C. Brown & Walter Lazisky	P.O. Box 422, Crescent City	Gasquet
Blue Creek Tunnel	R. H. Ellison	Weitchpec	Blue Creek
Dead Horse	Shirley Bros.	c/o Lennie Brooks, 2505 Portola Dr., Grants Pass, Ore.	O'Brien, Ore.
Eagles Nest & Edna	George Shicora	P.O. Box 803, Crescent City	Crescent City
Hambro	Hamilton Bros. Lumber Co.	P.O. Box 627, Crescent City	Smith River
Havilah Mill	W. B. Freeman	Rt. 3, Box 717, Grants Pass, Ore.	Gasquet
High Plateau	Tulare Mining Co.	731 Burgess St., Grants Pass, Ore.	Smith River
High Point & Blue Bird	Ernest G. Tarbell	Smith River	Smith River
Holiday	Holiday Mining Co.	Patricks Creek Inn	Patricks Creek
J. & W. (French Hill)	J. & W. Mining Co.	Box 164, Orick	French Hill
Judy, Eagle Pass, Victor, & Meadow	R. I. Hicks	Box 253, Cave Junction, Ore.	O'Brien, Ore.
Lower Coon Creek	Hamilton Bros. Lumber Co.	P.O. Box 627, Crescent City	Crescent City
Old Doe	Harold T. Funk	711 Greenwood Dr., Grants Pass, Ore.	Smith River
Peacock	A. G. Blackwell & H. W. Hill	Gen. Del., Smith River	Smith River
Silver Lead	Herman Weeks	Box 95, Scotts Bar	
Sunrise	Nealy Logging Co.	Box 361, Gasquet	Gasquet
White Spot	Bill Evit	O'Brien, Ore.	O'Brien, Ore.
Fresno County:			
Big Ridge	Joseph R. Holman	1465 E. Orange Grove Ave., Pasadena	Coalinga
Butler Estate	Southwest Oil Co.	802 W. 123d St., Los Angeles 44	Coalinga
Railroad	Bonnell Mining Co.	P.O. Box 942, Coalinga	Coalinga
Glenn County:			
Burrows	David Chalmers	P.O. Box 486, Elk Creek	Newville
Humboldt County:			
White Cedar	Dan Haight	Smith River	Klamath
Monterey County:			
Lilly Group	Monte Young & Son	Box 43, San Simeon	San Simeon

Napa County:			
Grub Stake	Clyde Davis	Rt. 1, Box 426, Redwood Valley	Pope Valley
White Angel	David Chalmers	P.O. Box 486, Elk Creek	Knoxville
Placer County:			
Daisy Belle	Joseph Delmue	Box 77, Foresthill	Foresthill
Eisenhower	J. J. & Elsie B. Stephenson	Pleasant Grove	Foresthill
Mountain View	Cliff Hills & Russell Powell	Michigan Bluff	Michigan Bluff
Pitt 47	Blake Teague	Gen. Del., Foresthill	Foresthill
Two Cedar	Frank Turner, Paul Beatty	P.O. Box 743, Foresthill	Foresthill
San Benito County:			
Saw Mill Creek	Hampton Mining Co.	Idria	Idria
Saw Mill Creek	James Mining Co.	1465 E. Orange Grove Ave., Pasadena	Idria
San Luis Obispo County:			
Castro	Castro Mining Co.	c/o Durand Hall, 625 Market St., San Francisco	San Luis Obispo
Castro, Norcross, & Sweetwater	John D. Hoffman	778 Marsh St., San Luis Obispo	San Luis Obispo
Hardface, Pick & Shovel & Trinidad	Pierce Bros.	P.O. Box 386, Morro Bay	Morro Bay
Jolon (Hearst Ranch)	James Collard	P.O. Box 251, Cambria	San Simeon
London	Harry J. Stevens	Box 186, Cayucos	San Luis Obispo
Sweetwater	Ruda & Negranti	Box 465, Cayucos	San Luis Obispo
Santa Barbara County:			
Corrales	Cachuma Mining Co.	P.O. Box 96, Santa Ynez	Santa Ynez
Davis	Davis Mining Co.	Rt. 1, Box 158, Santa Maria	Los Olivos
Siskiyou County:			
Blue Jay	T. E. Collins & Stephen Bloss	Box 622, Central Point, Ore.	Fort Jones
Blue Thorn	O. W. Gould & Henry Kaiser	Cecilville	Cecilville
Cyclone Gap	Ruth Robertson	Box 475, Grants Pass, Ore.	Happy Camp
Desperation	T. E. Collins	Box 622, Central Point, Ore.	Fort Jones
Dry Gulch	Virgil A. Grey	Box 9, Etna	Cecilville
Fairview	Ashland Mining Co.	835 N. Main St., Ashland, Ore.	Hamburg
Gazelle Mtn.	J. A. Richter	Box 293, Callahan	Callahan or Gazelle
Gunsite	Wendell Bussert	Happy Camp	Happy Camp
D. L. Hammond	Herbert Cameron	1881 SE. "N" St., Grants Pass, Ore.	Weed
Lady Grey	J. H. Watkins	Scotts Bar	Scotts Bar
Llano de Oro	Mormon E. Hatcher	Yreka	Yreka
McGuffy Creek & Mountain View	D. G. Thompson	Box 521, Yreka	Seiad
Mountain View	Herman Weeks	Box 95, Scotts Bar	Seiad
Mule Shoe	Ernest A. Hayden & G. Harrison	Callahan	Callahan
Munson	Floyd L. Munson	Box 315, Etna	Callahan
Oro Grande	Daniel W. Hatcher	Fort Jones	Fort Jones
Railroad Lease	Jack Hottendorf	Etna	Fort Jones
Rocky Gulch	Basil Wild	Box 342, Greenview	Fort Jones
S. & W.	Charles H. Tschoop	Fort Jones	Fort Jones
Seiad & Lady Grey	F. L. Merrill	Scotts Bar	Scotts Bar
Williamson claim	Carver Gepford	Box 18, Etna	Etna

Chromite—Continued

Mine	Operator	Address	Location
Stanislaus County:			
Del Puerto	Del Puerto Mining Co.	77 E. Santa Clara, San Jose	Patterson
Tehama County:			
Blue Sky, et al.	Beegum Mining Co.	4311 Rosedale Highway, Bakersfield	Platina
Blue Sky 4th of July	L. B. Duffin	3003 Lenard Way, Oakland	Platina
Grau lease	Dave Brundage	P.O. Box 603, Red Bluff	Red Bluff
Kleinsorge	Richland Mining Co.	P.O. Box 603, Red Bluff	Red Bluff
----------	Utah Chrome Co.	c/o A. H. Huber, Taber Bldg., Elko, Nev.	Platina
Trinity County:			
Cedar	Lee Chapman	Laytonville	Mad River
Redskin	Starr Bee Mines	Hayfork	Hayfork
Shamrock	Liston Ehorn	P.O. Box 41, Red Bluff	Wildwood

Clay

Operator	Address	Location
Alameda County:		
Bell Sand & Gravel (miscellaneous clay)	P.O. Box 282, Irvington	Irvington
California Pottery Co. (miscellaneous clay)	P.O. Box 68, Niles	Niles
Interlocking Roof Tile Co. (miscellaneous clay and shale)	Rt. 1, Box 488, Niles	Niles
Kraftile Co. (miscellaneous clay)	Niles	Niles
Amador County:		
Gladding, McBean & Co. (fire clay)	2901 Los Feliz Blvd., Los Angeles 39	Ione
Pacific Clay Products Co. (fire clay, miscellaneous clay)	1255 W. Fourth St., Los Angeles	Ione
Ione Clay and Sand Corp. (fire clay)	Ione	Ione
Western Refractories Co. (fire clay)	P.O. Box 169, Ione	Ione
Calaveras County:		
California Pottery Co. (miscellaneous clay, fire clay)	P.O. Box 68, Niles	Valley Springs
Pacific Clay Products Co. (fire clay)	1255 W. Fourth St., Los Angeles	Valley Springs

Contra Costa County:		
Port Costa Brick Works, C. G. Berg, Pres. (miscellaneous clay and shale)	401 Berry St., San Francisco 7	Port Costa
United Materials & Richmond Brick Co., Ltd., (miscellaneous clay and shale)	Box 7, Point Richmond 3	Richmond
Fresno County:		
Craycroft Brick Co. (miscellaneous clay)	P.O. Box 814, Fresno	Fresno
Inyo County:		
Multi Mines, Inc. (fullers earth)	2552 E. Olympic Blvd., Los Angeles 23	Tecopa
Rook & Mason (fullers earth)	P.O. Box 55, Shoshone	Olancha
Sierra Talc & Clay Co. (bentonite and fullers earth)	1608 Huntington Dr., South Pasadena	Olancha
Silicates Corp., L. R. Moretti, Trustee (bentonite)	100 Palm Ave., San Rafael	Death Valley Junction
Kern County:		
American Mineral Co. (miscellaneous clay)	840 S. Mission Rd., Los Angeles 23	Cantil
Excel Minerals Co. (diatomaceous clay)	3461 E. 26th St., Los Angeles	Taft
McKittrick Mud Co. (oil-well drilling mud)	Box 356, McKittrick	McKittrick
Mojave Corp. (oil-well drilling mud)	12827 E. Imperial Highway, Norwalk	Muroc
Los Angeles County:		
Angulo Tile Co. (miscellaneous clay)	P.O. Box 97, 19044 Kittridge St., Reseda	Reseda
Atkinson Brick Co. (miscellaneous clay)	13633 S. Central Ave., Los Angeles 59	Los Angeles
Builders Brick Co. (miscellaneous clay)	P.O. Box 266, Gardena	Compton
Castaic Brick Co. (miscellaneous clay and shale)	P.O. Box 180, Castaic	Castaic
Davidson Brick Co. (miscellaneous clay)	4701 E. Floral Dr., Los Angeles 22	Los Angeles
Gladding, McBean & Co. (miscellaneous clay)	2901 Los Feliz Blvd., Los Angeles 39	Tropico, Los Angeles, Santa Monica and Pico
Higgins Brick & Tile Co. (miscellaneous clay)	2217 W. 174th St., Torrance	Moneta
Dr. Leon N. Katz (miscellaneous clay)	9837 Foothill Blvd., San Fernando	Sunland
Maybow Building Materials & Suppliers, Inc. (miscellaneous clay)	P.O. Box 517, Harbor City	Los Angeles
Sun Valley Tile Kilns (miscellaneous clay, alluvium)	1258 N. Highland Ave., Los Angeles 38	Reseda
Star Brick Co. (miscellaneous clay)	17799 S. Western Ave., Gardena	Gardena
Valley Brick & Supply Co. (miscellaneous clay and loam)	6151 Kester Ave., Van Nuys	Van Nuys
Marin County:		
McNear Brick Co. (miscellaneous clay and shale)	P.O. Box 119, McNear Point, San Rafael	McNear Point
Mono County:		
Huntley Industrial Minerals (kaolin)	P.O. Box 305, Bishop	Laws

Clay—Continued

Operator	Address	Location
Orange County:		
I. P. Arnold (kaolin or china clay and fire clay)	7655 E. Second Ave., Downey	El Toro
B. B. Garret or Mission Clay Products Corp. (miscellaneous clay)	Box 132, 1696 E. Santiago Ave., Olive	Olive
Gladding, McBean & Co. (fire clay)	2901 Los Feliz Blvd., Los Angeles 39	Irvine, Claymont, Prado
La Bolsa Tile Co. (miscellaneous clay)	R.F.D. 18404 Gothard St., Huntington Beach	Smeltzer
Pacific Clay Products (miscellaneous clay)	1255 W. Fourth St., Los Angeles	Irvine
W. A. Schueppe (kaolin)	P.O. Box 101, El Toro	El Toro
Placer County:		
Gladding, McBean & Co. (fire clay)	2901 Los Feliz Blvd., Los Angeles 39	Lincoln
Lincoln Clay Products Co. (fire clay)	P.O. Box 367, Lincoln	Lincoln
Riverside County:		
Alberhill Coal & Clay Co. (fire clay)	P.O. Box 431, Claremont	Alberhill
Atlas Sewer Pipe Co. (miscellaneous clay)	10009 S. Painter St., Whittier	Corona
Joe Deleo, Jr., contractor (fire clay and miscellaneous clay)	1233 Garretson Ave., Corona	Temescal Canyon
Elsinore Clay Co. (fire clay)	Highgrove	Elsinore
Gladding, McBean & Co. (fire clay and miscellaneous clay)	2901 Los Feliz Blvd., Los Angeles 39	Corona and Elsinore
Liston Brick Co. (miscellaneous clay)	P.O. Box 7, Corona	Corona
Los Angeles Brick & Clay Products Co. (fire clay and miscellaneous clay)	1078 N. Mission Rd., Los Angeles 33	Alberhill
Pacific Clay Products (fire clay)	1255 W. Fourth St., Los Angeles	Corona
John Tillotson, dba Sky Ranch Clay Co. (fire clay)	P.O. Box 398, Corona	Corona
Sacramento County:		
Cannon Co. (miscellaneous clay)	Box 802, Sacramento 4	Ben Ali and Michigan Bar
Harrison Fait (adobe)	1950 Howe Ave., North Sacramento 21	North Sacramento
Sacramento Brick Co. (miscellaneous clay and adobe)	P.O. Box 844, Sacramento 4	Sacramento
J. J. Robideaux (fire clay)	4805 Yosemite Ave., Sacramento	Near Ione
San Bernardino County:		
B. & W. Tile Mfg. Co. (ball clay)	14600 S. Western Ave., Gardena	Ivanpah
J. S. Barrett (bentonite)	1230 St. Gertrude Place, Santa Ana	Yermo
Baroid Sales Division, National Lead Co. (bentonite)	P.O. Box 1675, Houston 1, Texas	Hector
Brown Minerals Co. (bentonite)	4553 N. Kassebaum Ave., El Monte	Vidal
Gladding, McBean & Co. (kaolin or china clay)	2901 Los Feliz Blvd., Los Angeles 39	Goff
Hancock Brick Co. (miscellaneous clay and adobe)	Highgrove	Highgrove
Inerto Co. (bentonite)	1489 Folsom St., San Francisco 3	Newberry
Pomona Brick Co. (miscellaneous)	P.O. Box 239, Pomona	Chino
Southern California Minerals Co., W. K. Skeoch (ball clay)	320 S. Mission Rd., Los Angeles 33	Baker

San Diego County:		
Hazard Bloc Co. (miscellaneous clay)	Cabrillo Freeway and Friars Rd., Mission Valley, San Diego	San Diego
Sorrento Brick & Clay Products, Inc. (miscellaneous clay)	Box 183, Sorrento	San Diego
Union Brick Co. (miscellaneous clay and shale)	7351 Pacific Highway, San Diego 9	Rose Canyon
San Joaquin County:		
Stockton Brick & Tile Co. (miscellaneous clay)	P.O. Box 547, Stockton	Stockton
Stockton Building Materials (miscellaneous clay)	711 S. Madison St., Stockton 4	Stockton
San Luis Obispo County:		
Faulstich Bros., San Luis Brick, Inc. (miscellaneous clay)	Box 122-D, Rt. 2, San Luis Obispo	San Luis Obispo
Santa Barbara County:		
McNall Building Materials (miscellaneous clay and shale)	P.O. Box 758, Santa Barbara	San Marcos
Santa Clara County:		
Gladding Bros. Mfg. Co. (miscellaneous clay)	P.O. Box 88, S. Third and Keyes St., San Jose 12	San Jose
Remillard-Dandini Co. (miscellaneous clay)	Storey Road, San Jose	San Jose
Solano County:		
Basalt Rock Co., Inc. (miscellaneous clay and shale)	Eighth and River Sts., Napa	Chabot Acres
Sonoma County:		
Joe Malugani (miscellaneous clay)	581 Silva Ave., Santa Rosa	Mark West
Stanislaus County:		
Clayton and Lester Raggio (fire clay)	Box 27, Knights Ferry	Cooperstown
Sutter County:		
Gladding, McBean & Co. (miscellaneous clay)	2901 Los Feliz Blvd., Los Angeles 39	Nicolaus
Tulare County:		
S. P. Brick & Tile Co. (miscellaneous clay)	P.O. Box 568, Fresno	Exeter
Ventura County:		
Ridgelite Products, Inc. (miscellaneous clay)	P.O. Box 723, Arcadia	Frazier Park
Rocklite Products (shale)	1800 N. Ventura Ave., Ventura	Ventura
Shell Oil Co., Dent clay pit (oil well drilling mud)	Shell Bldg., San Francisco	Ventura

Coal

Operator	Address	Location
Amador County:		
American Lignite Products Co.	Ione	Ione

Copper

Mine	Operator	Address	Location
Amador County:			
Copper Hill	Fitzgerald, Smith & Assoc.	P.O. Box 586, Placerville	Plymouth
Calaveras County:			
Calaveras Copper	Union Copper Co.	Box 36, Copperopolis	Copperopolis
Penn	Standard Mining Co.	Campo Seco	Campo Seco
El Dorado County:			
Noonday	Fitzgerald, Smith & Assoc.	P.O. Box 586, Placerville	Diamond Springs
Inyo County:			
Darwin and Shoshone	The Anaconda Co.	25 Broadway, New York, N. Y.	Darwin and Shoshone
Lippincott	Lippincott Lead Mines	P.O. Box 1811, Santa Ana	Ubehebe
Pine Creek	Union Carbide Nuclear Co., Division of Union Carbide & Carbon Corp.	30 E. 42d St., New York 17, N. Y.	Bishop
Santa Rosa	Norris & Bracken	Box 395, Lone Pine	Keeler
Santa Rosa	Thomas D. Norris	P.O. Box 111, Keeler	Keeler
Madera County:			
Jesse Belle	Delta Mining Co., F. S. Herring	2728 "H" St., Merced	Daulton
San Bernardino County:			
Horn Group	Globe Uranium, Inc.	1888 N. Crescent Heights Blvd., Los Angeles	Turtle Mtn.
New Trail	Jumbo Cycle Sales Inc.	Box 12, Brea	Nipton
Shasta County:			
Afterthought	M. D. Jordan	2852 Flower Ave., Ogden, Utah	Ingot
Trinity County:			
Rainbow	Hoover Drilling Co.	3800 Pierce Rd., Bakersfield	Trinity Center

Diatomite (Diatomaceous Earth)

Operator	Address	Location
Los Angeles County:		
Great Lakes Carbon Corp., Dicalite Division	612 S. Flower St., Los Angeles 17	Palos Verdes
Napa County:		
Basalt Rock Co., Ltd.	Eighth and River Sts., Napa	Napa
Santa Barbara County:		
Airox Company	307 W. Eighth St., Los Angeles 14	Casmalia
Grant & Grant Engineering	P.O. Box 1206, Lompoc	Lompoc
Great Lakes Carbon Corp. Dicalite Division	612 S. Flower St., Los Angeles 17	Lompoc
Johns-Manville Products Corp.	22 E. 40th St., New York, N. Y.	Lompoc

Feldspar

Operator	Address	Location
Monterey County:		
Del Monte Properties Co.	P.O. Box 150, Pacific Grove	Pacific Grove
San Bernardino County:		
Gladding, McBean & Co.	2901 Los Feliz Blvd., Los Angeles 39	Atolia

Gold

Mine	Type of mine	Operator	Address	Location
Calaveras County:				
McCarty	d	Mountain Gold Dredging Co.	Sutter Creek	Valley Springs
El Dorado County:				
Hazel Creek	a	Hazel Creek Mining Corp.	P.O. Box 3508, North Sacramento	Sly Park
Fresno County:				
Rockfield Gravel Plant	g	Kerkling & Slensker	1800 Denver St., Lakewood, Colo.	Friant
Inyo County:				
Darwin Group	l	The Anaconda Co.	P.O. Box 58, Darwin	Darwin
Pine Creek	t	Union Carbide Nuclear Co. (A division of Union Carbide & Carbon Corp.)	Rm. 2115, 30. E. 42d St., N. Y. 17, N. Y.	Bishop
Shoshone Group	l	The Anaconda Co.	P.O. Box 58, Darwin	Shoshone
Kern County:				
Burton Mill	c	Burton Mines, Inc.	Rosamond	Rosamond
Golden Buddha	a	Golconda Metals Dev. Corp.	P.O. Box 885, Lancaster	Mojave
Silver Queen	s	Oscar's Queen Lease, J. C. Stoel, G. F. Jenkins, H. Wright	P.O. Box 415, Mojave	Mojave
Yellow Aster	a	Wm. A. Stryker and Louis E. Harrel	P.O. Box 264, Johannesburg	Randsburg
Los Angeles County:				
Azusa Rock & Sand Co.	g	San Gabriel Valley Placers	1237 S. Greenwood Ave., Montebello	Montebello
Consolidated Rock Co.	g	Consolidated Rock Products Co.	P.O. Box 2950, Terminal Annex, Los Angeles	Azusa
Mariposa County:				
Nelly Kaho	a	Harmon & Dozier Mining Co.	Box 952, Mariposa	Bear Valley
Pine Tree	c	Pacific Mining Co.	2801 Oak Knoll, Berkeley 5	Bear Valley
Red Banks	a	Chris Mills	c/o Bagby Store, Mariposa	Bagby

Nevada County:				
Brunswick	a	Idaho Maryland Mines Corp.	P.O. Box 1028, Grass Valley	Grass Valley
Empire North Star Group	a	Empire Star Mines Co., Ltd.	P.O. Box 1027, Grass Valley	Grass Valley
Little Fort Knox	a	Jack Sutherland	P.O. Box 919, Grass Valley	Grass Valley
St. Louis Tunnel	a	Willow Valley Mines, Inc.	Geo. Pettigrew, Sec., 461 Market St., San Francisco	Nevada City
Sacramento County:				
Haggin Gravel Pit	g	Macklin Mining Co.	520 Harbor Blvd., Sacramento	Mills
Natomas	b	Natomas Co. et al.	P.O. Box 1197, Sacramento	Folsom
Perkins Gravel Pit	g	Perkins Gravel Co.	1931 Stockton Blvd., Sacramento	Perkins
Shasta County:				
Oscar Davis Property (Olson dredge)	d	Roy S. Olson	1178 Walnut Ave., Redding	Redding
Sierra County:				
Brush Creek	a	Best Mines Co., Inc.	P.O. Box 177, Downieville	Goodyear Bar
Original Sixteen to One	a	Original Sixteen to One Mine, Inc.	Alleghany (or 1611 Russ Bldg., San Francisco)	Alleghany
Siskiyou County:				
Hayden	d	Scott River Dredging Co.	625 Market St., San Francisco	Callahan
Siskon	a	Siskon Corp.	Box 148, Happy Camp	Happy Camp
Trinity County:				
Fairview Placers	b	Fairview Placers	Lewiston	Minersville
Tuolumne County:				
Eureka (Grizzley Eureka)	m	Charles F. Harper	Box 45, Big Oak Flat	Priest
Yuba County:				
Yuba Unit	b	Yuba Consolidated Gold Fields	351 California St., San Francisco	Hammonton

LEGEND

a—lode gold mine
b—bucket line dredge
c—clean up
d—dragline
g—gravel pit
l—lead zinc mine
m—mine dump
s—gold silver mine
t—tungsten mine

Granite (Dimension Stone)

Operator	Address	Location
Fresno County:		
Superior Academy Granite Co.	P.O. Box 68, Clovis	Academy
Madera County:		
Raymond Granite Co.	Raymond	Raymond
Placer County:		
Union Granite	P.O. Box 819, Rocklin	Rocklin
San Diego County:		
Clement Granite Co.	3600 Suncrest Blvd., El Cajon	Suncrest
Escondido Quarries, Inc.	530 W. Sixth St., Los Angeles	Escondido
National Quarries	923 Park Hill Dr., Escondido	Escondido
Valley Granite Co.	243 E. Fifth St., Escondido	Escondido

Gypsum

Operator	Address	Location
Alameda County:		
Westvaco Mineral Products Division, Food Machinery & Chemical Corp. (output not included in production figures as gypsum is by-product of chemical process using minerals already included in state total).	P.O. Box 337, Newark	Newark
Imperial County:		
United States Gypsum Co.	300 W. Adams St., Chicago, Ill.	Plaster City
Kern County:		
Antelope Valley Agricultural Gypsum Co.	P.O. Box 535, Rosamond	Cantil
Agricultural Gypsum Mine, C. L. Fannin	Rt. 1, Box 7, Wasco	Wasco
H. M. Holloway	714 Sixth St., Wasco	Lost Hills
Mel Northington	1122 Castiac Ave., Oildale	Belridge
Superior Gypsum Co.	3916 Pierce Rd., Bakersfield	Lost Hills
Temblor Gypsum Co.	Sta. Rt. Box 80, Santa Margarita	Carrizo Plains

Kings County:		
McPhaill Gypsum Co.	P.O. Box 927, Visalia	Avenal
Merced County:		
Agricultural Mineral & Fertilizer Co., A. D. Sousa	P.O. Box 832, Los Banos	Los Banos
Riverside County:		
United States Gypsum Co.	300 W. Adams St., Chicago 6, Ill.	Midland
San Luis Obispo County:		
Superior Gypsum Co.	3916 Pierce Rd., Bakersfield	Carrizo Plains
Ventura County:		
Monclith Portland Cement Co.	Box 65947 Glassell Sta., Los Angeles 65	Quatal Canyon

Iodine

Operator	Address	Location
Los Angeles and Orange Counties:		
Deepwater Chemical Co., Ltd.	Box 588, Compton	Compton
Western Division, The Dow Chemical Company	P.O. Box 245, Seal Beach	Long Beach, Venice, and Seal Beach

Iron

Mine	Operator	Address	Location
Riverside County:			
Eagle Mountain	Kaiser Co., Inc.	Box 217, Fontana	Desert Center
San Bernardino County:			
Iron Age	Iron Age Mines Co.	Twentynine Palms	Amboy
Cave Canyon	Mineral Materials Co.	1145 Westminister Ave., Alhambra	Baxter

Lead

Principal lead producers in California in 1956
(Not less than 10,000 pounds per year)

Mine	Operator	Address	Location
El Dorado County:			
Hazel Creek	Hazel Creek Mining Corp.	P.O. Box 3508, North Sacramento	Sly Park
Inyo County:			
Christmas Gift, Lucky Jim, and Promontory (dumps)	Louis Warnken, Jr.	Lone Pine	Darwin
Darwin group	The Anaconda Co.	25 Broadway, New York, N. Y.	Darwin
Defense	Foreman & Foreman	P.O. Box 175, Darwin	Panamint Springs
Lippincott (Lead King)	Lippincott Lead Mines	Box 1811, Santa Ana	Scotty's Castle
Santa Rosa	Norris & Bracken	P.O. Box 395, Lone Pine	Big Pine
Santa Rosa	Thomas D. Norris	P.O. Box 111, Keeler	Big Pine
San Bernardino County:			
San Antonio	William Olds	c/o Allsop & Johnson, 942 Carson St., Barstow	Barstow
Shasta County:			
Afterthought	M. D. Jordan	2852 Fowler Ave., Ogden, Utah	Ingot

Lime, Limestones, and Shells

Operator	Address	Location
El Dorado County:		
California Rock & Gravel Co. (industrial limestone)	1800 Hobart Bldg., San Francisco 4	Newcastle
Diamond Springs Lime Corp. (producer of burnt lime, industrial limestone, and agricultural lime)	Box 409, Diamond Springs	Diamond Springs
El Dorado Limestone Co. (industrial limestone)	Shingle Springs	Shingle Springs
Inyo County:		
West End Chemical Co., Division of Stauffer Chemical Co. (industrial limestone)	1956 Webster St., Oakland 12	Argus Range

Monterey County:		
Kaiser Aluminum & Chemical Corp. (producer of burnt lime and dolomite)	Box 1531, Salinas	Salinas
Riverside County:		
Riverside Cement Co. (industrial limestone)	621 S. Hope St., Los Angeles 17	Crestmore
San Benito County:		
Westvaco Mineral Products Division, Food Machinery Corp. (dolomite)	P.O. Box 337, Newark	Hollister
San Bernardino County:		
California Dolomite Co. (refractory dolomite)	17619 S. Clark, Bellflower	Adelanto, Kramer
California Portland Cement Co. (producer of burnt lime and industrial limestone)	612 S. Flower St., Los Angeles 17	Colton
Standard Mineral Materials Co. (flux)	1145 Westminister Ave., Alhambra	Cushenbury
Victorville Lime Rock Co. (industrial limestone)	Box 548, Victorville	Victorville
West End Chemical Co., Division of Stauffer Chemical Co. (producer of burnt lime)	1956 Webster St., Oakland 12	Westend
San Luis Obispo County:		
Eaton & Smith (sugar rock)	1215 Michigan Ave., San Francisco	Lime Mountain
San Mateo County:		
South Bay Dredging Co., c/o P. J. Gambetta (shells)	Rt. 1, Box 894, Santa Clara	San Francisco Bay
Pioneer Shell Co. (shells)	100 E. D St., Petaluma	San Mateo
Santa Barbara County:		
G. Antonini & Sons (building stone)	131 E. Gutierrez St., Santa Barbara	Santa Maria
Santa Clara County:		
South Bay Dredging Co. c/o P. J. Gambetta (shells)	Rt. 1, Box 894, Santa Clara	San Francisco Bay
Santa Cruz County:		
Pacific Limestone Prod. Co. (industrial limestone and agricultural lime)	P.O. Box 468, Santa Cruz	Santa Cruz
Santa Cruz Portland Cement Co. (industrial limestone)	Crocker Bldg., San Francisco	Davenport
Tuolumne County:		
Sonora Marble Aggregates Co. (industrial limestone)	Rt. 1, Box 599, Sonora	Sonora
U. S. Lime Products Corp. (producers of burnt lime, industrial limestone, agricultural lime, and dolomite)	2244 Beverly Blvd., Los Angeles 57	Sonora
Ventura County:		
Western Lime Products Co. (industrial limestone and agricultural limestone)	520 Mission St., South Pasadena	Santa Susana

Lithia

Operator	Address	Location
San Bernardino County:		
American Potash & Chemical Corp.	3030 W. Sixth St., Los Angeles 54	Trona

Magnesia and Other Magnesium Compounds

Operator	Address	Location
Alameda County:		
Westvaco Mineral Products Division, Food Machinery & Chemical Corp.	P.O. Box 337, Newark	Newark
Monterey County:		
Kaiser Aluminum & Chemical Corp. (oxide)	Box 1531, Salinas	Moss Landing
San Diego County:		
Westvaco Mineral Products Division, Food Machinery & Chemical Corp.	P.O. Box 337, Newark	Chula Vista
San Mateo County:		
Marine Magnesia Products Division, Merck & Co. (carbonate, hydroxide, and oxide)	E. Grand Ave., South San Francisco	South San Francisco

Magnesite

Operator	Address	Location
Santa Clara County:		
James McPeters	Star Route, Box 39, Livermore	Red Mountain

Manganese

Mine	Operator	Address	Location
Imperial County:			
Black Jet	Donald F. Lockwood	Box 16, Palo Verde	Palo Verde
Black Point & Tadpole	Walter S. Thing	Star Rt., Ripley	Palo Verde
Pioneer	L. Mills Beam	10535 Buford Ave., Inglewood	Blythe
Lake County:			
Tex Young	Tex Young Mines	Box 101, San Mateo	Ukiah
Mendocino County:			
South Thomas	S. & C. Mining Co., Bay Hubman	510 Hobart Bldg., San Francisco	Ukiah
Plumas County:			
Mt. Hough	William L. Ash	646 Second St., Colusa	Quincy
Riverside County:			
Black Jack	Aspen Mining Co., c/o James V. Thompson	910 First National Bank Bldg., Denver, Colo.	Blythe
Langdon, Blue Chief, etc.	California Limestone Products	139 S. Beverly Dr., Beverly Hills	Blythe
------	Roberts & Stewart	Blythe	Blythe
San Bernardino County:			
Owl Head	Owl Springs Co., Inc.	2001 W. Artesia Blvd., Torrance	Baker
San Luis Obispo County:			
Johe Ranch	Porter L. Jackman and Bob Bianchini	Rt. 1, Box 161B, San Luis Obispo	San Luis Obispo
Trinity County:			
Berry Creek	Walter Wells & Pat Jordan	3242 School St., Redding	Ruth
Pearson	R. W. Mathews & Ray Pearson	Box 77, Eureka	Ruth
Trout Creek	K.P.F. & F. Mining Co.	Box 1, Igo	Ruth

Mercury (Quicksilver)

Mine	Operator	Address	Location
Del Norte County:			
Webb	A. Folkins & Howard Muloney	Patricks Creek Inn	Patricks Creek
Fresno County:			
Alhreo	Albert L. Prichard	P.O. Box 853, San Jose	Mercey Hot Springs
Archer	J. M. Koski	Idria	Coalinga
Archer	Chris Miranda & Joe Rios	137 Washington St., Coalinga	Coalinga
Esperanza	Leonard W. Knepper	P.O. Box 87, Idria	Idria
Kings County:			
Fredanna & Little Kings	Roy Pierce & J. Peterson	124 Atkinson Lane, Watsonville	Parkfield
Lake County:			
Abbott	California Quicksilver Mines Inc., C. O. Reed, Mgr.	Williams	Wilbur Springs
Baker	Fred Story	P.O. Box 127, Lower Lake	Lower Lake
Big Chief	Mercury Mining Co.	P.O. Box 424, Middletown	Anderson Springs
Big Injun	Louise Janus & E. Johnson	P.O. Box 232, Hopland	Anderson Springs
Helen	Helen Mining Co.	1215 Michigan St., San Francisco	Middletown
Joyce property	Stevens Mining Co.	Rt. 1, Box 623, Florin	Middletown
Mirabel	Allen Burdick	570 S. Monroe, San Jose	Middletown
Sulphur Bank	Bradley Mining Co.	660 Market St., San Francisco	Clearlake Oaks
Wall Street	Liquid Metal Oil & Gas	Middletown	Middletown
Marin County:			
Edwards	Floyd Edwards & Bros.	1808 Fulton Ave., Santa Rosa	Marshall
Turner & McFarland	Turner & McFarland	2005 Webster Ave., Petaluma	Petaluma
Merced County:			
Stayton	Burgen & Oleson	P.O. Box 83, Hollister	Hollister
Monterey County:			
Old Murry	Monty Young	San Simeon	San Simeon
Patriquin	New Patriquin Mining Assoc.	P.O. Box 64, Soledad	Parkfield
Napa County:			
James Creek Placers	Paul Sharrocle	P.O. Box 338, Whispering Pines	Aetna Springs
James Creek Placer	Harold H. Zehr	Pope Valley	Pope Valley
Mad Money	Russe & Keel	630 Vendola Dr., San Rafael	Pope Valley
Oat Hill Dump	W. T. Kritikos	3118 W. Euclid, Stockton	Aetna Valley
Oat Hill Dump	Vincent Yracabel et al	P.O. Box 17, Middletown	Aetna Valley

Pope Creek	Charles S. Bunting	Pope Valley	Pope Valley
Toyon	Toyon Mining Co., Alvin M. Bentley	Rt. 1, Box 150, Calistoga	Aetna Valley
Vian	Harold Vian	188 Smedley Ave., Hayward	Pope Valley
San Benito County:			
Aurora	Jerome	P.O. Box 87, Idria	Idria
Dar	Louis & Don Sciocchetti	P.O. Box 637, Hollister	Paicines
El Cajon (Clough)	Matthews Mining Co.	135 Vine St., Hollister	Panoche
Juniper	Louis Sciocchetti	P.O. Box 637, Hollister	Paicines
Lucky Strike	Cinnabar Engineer Co.	Panoche	Panoche
New Idria	New Idria Mining & Chemical Co.	P.O. Box 87, Idria	Idria
Nona	Nona Mining Co.	San Benito	Hernandez
North Star & San Carlos	Leonard W. Knepper	P.O. Box 87, Idria	Idria
San Carlos	T. W. Marshall & Juan Carrillo	231 Monterey Rd., Salinas	Idria
Santa Margarita	Juan P. Carrillo et al.	231 Monterey Rd., Salinas	Hernandez
Turkey Hill	R. A. Fones	930 E. First St., Livermore	Paicines
Wonder	Herman W. Hass & Robert L. Lee	708 Francis St., Seaside	Idria
San Luis Obispo County:			
Keystone	Herbert Flannery & Noe Washabaugh	Rt. 1, Box 44A, Paso Robles	Cambria
Klau	Klau Mines, Inc.	709 Union St., San Francisco	Adelaida
La Libertad	Fitzhugh & Osborn Mining Co.	P.O. Box 208, Templeton	Adelaida
Madrone	Victor V. Botts	Creston Rt., Paso Robles	Adelaida
Oceanic	Frank Vollmer	Box 281, Cambria	Cambria
Polar Star	Kenneth Emigh	Soquel and Front Sts., Santa Cruz	San Simeon
San Mateo County:			
Farm Hill	Challenge Mining Co.	727 Shasta St., Redwood City	Redwood City
Farm Hill	A. F. Oddstad, Jr.	727 Shasta St., Redwood City	Redwood City
Santa Barbara County:			
Gibralter	Gibralter Mining Co.	15518 Lakewood Blvd., Paramount	Santa Barbara
Red Rock	Edward M. Smith	Los Olivos	Los Olivos
Santa Clara County:			
Guadalupe & Hillsdale	Palo Alto Mining Corp.	14900 Coleman Rd., San Jose 24	Almaden and San Jose
New Almaden Dump	Byerly & Thompson	Rt. 2, Box 252, Morgan Hill	Almaden
New Almaden Dump	James Tobar	422 E. Empire St., Almaden	Almaden
New Almaden Dump	Almaden Mine (Mrs. Harry Austin)	Almaden	Almaden
New Almaden Dump	Crystal Ball Mining Co.	21660 Bortram Rd., San Jose	Almaden
New Almaden Dump	Gish Bros.	455 S. 12th St., San Jose	Almaden
New Almaden Dump	Harold Hughes	Rt. 1, Box 176, San Martin	Almaden
New Almaden Dump	George Kirk	16268 San Jose Rd., Los Gatos	Almaden
New Almaden Dump	La Purissima Mining Co.	14164 Almaden Rd., Los Gatos	Almaden
New Almaden Dump	Harry Mobley & Frank Thompson	Rt. 1, Box 174, San Martin	Almaden
New Almaden Dump	Frank Pfeiffer	18931 Graystone Lane, Los Gatos	Almaden
New Almaden Dump	Lorenzo Rameriz	Almaden	Almaden

Mercury (Quicksilver)—Continued

Mine	Operator	Address	Location
Sonoma County:			
Buckman Group	Buckman Mines, Division of Buckman Laboratories, Inc.	1256 N. McLean, Memphis 8, Tenn.	Cloverdale
Mt. Jackson & Great Eastern	Sonoma Quicksiler Mines, Inc.	P.O. Box 226, Guerneville	Guerneville
Shamrock	Shamrock Mining Co.	c/o Geo. Topliff, 241 Jones St., San Francisco	Healdsburg
Stanislaus County:			
Adobe	Josef Odermatt	Box 972, Patterson	Patterson
Trinity County:			
Altoona	Austin & Smith	Mills Bldg., San Francisco	Trinity Center
Altoona	Philip Munko	715 Florence Ave., Dunsmuir	Trinity Center
Integral	Integral Mining Co.	P.O. Box 406, Middletown	Castella
Shasta Lily	A. Y. Cripps	Washington	Castella

Molybdenum

Mine	Operator	Address	Location
Inyo County:			
Pine Creek	Union Carbide Nuclear Co.	30 E. 42d St., New York 17, N. Y., Attn. W. E. Smith	Bishop

Peat

Operator	Address	Location
Contra Costa County:		
Delta Dredging Co.	Rt. 1, Box 894, Santa Clara	Brentwood
Vita Peat, Inc.	P.O. Box 255, Bethel Island	Bethel Island
Modoc County:		
Modoc Peat Moss Co.	604 Mission St., San Francisco 5	Likely
Orange County:		
R. W. McClellan and Sons	151 Commercial Way, Costa Mesa	Costa Mesa
Peat Sales Co., D. M. Callis, Jr.	17581 Gothard Rd., Huntington Beach	Huntington Beach

Perlite

Operator	Address	Location
Contra Costa County:		
Kaiser Gypsum Co., Inc. (expanded)	1924 Broadway, Oakland	Antioch
Fresno County:		
Perlite Products (expanded) Triestsch & Clark Inc.	93 Van Ness Ave., Fresno	Fresno
Inyo County:		
International Minerals & Chemical Corp. (crude)	3107 S. La Cienega Blvd., Los Angeles	Fish Springs
Los Angeles County:		
International Minerals and Chemical Corp. (expanded)	3107 S. La Cienega Blvd., Los Angeles	Los Angeles
Kaiser Gypsum Co., Inc. Long Beach Hill (expanded)	1924 Broadway, Oakland	Long Beach
Marcus A. McClure Co. (expanded)	35 N. Raymond Ave., Pasadena 1	Los Angeles
Panacalite Pacific, Inc. (expanded)	825 E. 60th St., Los Angeles 11	Los Angeles
Paramount Perlite Co., Inc. (expanded)	16236 S. Illinois, Paramount, P.O. Box 83	Paramount
Perlite Popped Products (expanded)	12655 E. Imperial Highway, Norwalk	Norwalk
Redco, Inc. (expanded)	11831 Vose St., North Hollywood	North Hollywood
Marin County:		
Perolite Products Corp. (expanded)	P.O. Box 175, Sausalito	Sausalito
Napa County:		
Perlite Aggregates, Inc. (crude and expanded)	P.O. Box 3, Sta. A., Berkeley 2	St. Helena
Riverside County:		
More-Lite Co. (expanded)	R.F.D. 5, Box 101-B, Crestmore via Riverside	Crestmore
San Bernardino County:		
California Perlite Corp. (crude)	228, 35 N. Raymond Ave., Pasadena 1	Ludlow
San Diego County:		
Harborlite Corp. (expanded)	P.O. Box 458, Escondido	Chula Vista

Platinum Group Metals

Operator	Address	Location
Sacramento County:		
Natomas Company	Box 1197, Sacramento	Folsom
Yuba County:		
Yuba Consolidated Gold Fields	351 California St., San Francisco	Hammonton

Potash

Operator	Address	Location
Contra Costa County:		
A. M. Blumer	465 California St., San Francisco	Cowell
San Bernardino County:		
American Potash and Chemical Corp.	3030 W. Sixth St., Los Angeles 54	Trona
Santa Cruz County:		
A. M. Blumer	465 California St., San Francisco	Davenport

Pumice and Pumicite

Operator	Address	Location
Fresno County:		
Fresno Pumi-Tile Co. (pebble pumice)	1503 Thesta St., Fresno	Friant
Imperial County:		
Superlite Builders Supply Co. (pumice and pumicite)	P.O. Box BB, Calipatria	Calipatria
Inyo County:		
Crownite Corp. (pumice)	6363 Wilshire Blvd., Los Angeles 48	Coso Junction
Redlite Aggregate, Ltd. (volcanic cinder)	111 N. La Cienega Blvd., Beverly Hills	Little Lake
Paul R. Splane Co. (volcanic cinders)	490 S. San Vicente Blvd., Los Angeles 48	Little Lake
Transmix Corp. (pumicite) dba Transit Mixed Concrete Co.	3464 E. Foothill Blvd., Pasadena 8	Bishop

Kern County:		
Calsilco Corp. (pumice)	2372 S. Atlantic Blvd., Los Angeles 32	Red Rock Canyon
Lake County:		
V. V. Coleman (pumice and volcanic cinders)	Lower Lake	Lower Lake
Lassen County:		
Mt. Lassen Cinder Co. (volcanic cinders)	903 Cottage St., Susanville	Susanville
Madera County:		
California Industrial Mineral Co. (pumicite)	P.O. Box 188, Friant	Friant
Elmer Erickson (pumice)	P.O. Box 98, Friant	Friant
Ol' Rebel Minerals Inc. (pumicite)	140 Harvard St., Fresno 5	Friant
Modoc County:		
Great Northern Railway Co. (volcanic cinders)	175 E. Fourth St., Saint Paul 1, Minn.	Tionesta
U. S. Pumice Supply Co. Inc. (pumice)	6331 Hollywood Blvd., Los Angeles 28	Tulelake
Mono County:		
Andrew Boyde (pumice) [a]	Box 572, Bishop	Laws
[a] leased Industrial Aggregate Co. mine and mill June 1, 1954		
Cowan & McGraw (pumice)	P.O. Box 1013, Bishop	Benton
U. S. Pumice Supply Co. (pumice, scouring blocks)	6331 Hollywood Blvd., Los Angeles 28	Lee Vining
San Bernardino County:		
Atchison, Topeka, and Santa Fe Railroad (scoria, cinders)	121 E. Sixth St., Los Angeles 14	Pisgah Cinder pit
John J. Ravese (pumicite)	P.O. Box 1048, Palm Springs	Hinkley
Williams Bros. (pumice)	R.F.D. 1, Barstow	Hinkley
Shasta County:		
Harry and Ivy Horr (volcanic cinders)	Glenburn	Glenburn
M. H. Moore (volcanic cinders)	Hat Creek	Hat Creek
Bert C. Peeler (volcanic cinders)	P.O. Box 131, McArthur	Red Butte
Siskiyou County:		
McCloud River Lumber Co. (pumicite)	McCloud	Hambone
John Madsen (Skoria Star Brick Co.) (pumice, scouring blocks, scoria)	P.O. Box 711, Klamath Falls, Ore.	Glass Mountain
Shastalite Block Co. (volcanic cinders)	300 N. Main St., Yreka	Cinder Cone Mountain
Southern Pacific RR Co. (volcanic cinders)	65 Market St., San Francisco	Kegg
Thompson Pumice Co. (pumice)	Star Rt. Box 10, Tulelake	Tionesta
U. S. Pumice Supply Co. Inc. (pumice)	6331 Hollywood Blvd., Los Angeles 28	Glass Mountain

Pyrite

Operator	Address	Location
Shasta County:		
The Mountain Copper Co., Ltd., L. T. T. Kett, Jr., Mgr.	230 California St., San Francisco 4	Matheson

Rare Earth Minerals

Operator	Address	Location
San Bernardino County:		
Molybdenum Corp. of America	500 Fifth Ave., New York, N. Y.	Mountain Pass

Salt

Operator	Address	Location
Alameda County:		
American Salt Co.	341 Broadway, San Francisco 11	Mt. Eden
Leslie Salt Co.	505 Beach St., San Francisco 11	Newark & Mt. Eden
Morton Salt Co.	120 S. La Salle St., Chicago, Ill.	Newark
Oliver Bros. Salt Co.	P.O. Box 132, Mt. Eden	Mt. Eden
Kern County:		
Long Beach Salt Co.	2476 Hunter St., Los Angeles 21	Saltdale
Monterey County:		
Monterey Bay Salt Works, E. C. Vierra, Mgr.	Box 43A, Moss Landing	Moss Landing
Orange County:		
Western Salt Co.	P.O. Box 149, San Diego 12	Newport Beach
San Bernardino County:		
California Salt Co.	2436 Hunter St., Los Angeles 21	Amboy
Metropolitan Water District of Southern California	306 W. Third St., Los Angeles 13	Rice
Pacific Salt & Chemical Co.	P.O. Box 9128, Sta. S, Los Angeles 5	Trona
San Diego County:		
Western Salt Co.	P.O. Box 149, San Diego 12	Chula Vista
San Mateo County:		
Leslie Salt Co.	505 Beach St., San Francisco 11	Redwood City

Sand, Gravel, and Stone, Miscellaneous

Under the heading of "miscellaneous stone" are four divisions—crushed rock, grinding mill pebbles, paving blocks, and sand and gravel. Crushed rock includes crushed rock that is used in macadam, ballast, and for concrete; also rock used for rubble and riprap.

NOTE—The California State Highway Commission, the various counties, cities, U. S. Engineers, U. S. Bureau of Reclamation, U. S. Forest Service, U. S. National Park Service, and U. S. Bureau of Public Roads produce both crushed rock and sand and gravel in various places in the state used in construction and maintenance of highways, but not specified in this listing.

Operator	Products	Address	Location
Alameda County:			
Bell Sand & Gravel Co.	s & g	P.O. Box 282, Irvington	Irvington
California Rock & Gravel Co.	s & g	1800 Hobart Bldg., San Francisco	Livermore
Clements Construction Co.	s & g	P.O. Box 667, Fremont	
Concrete Service Co.	s & g	860 Sunol St., San Jose	Sunol
Deetz Sand & Gravel Co.	s & g	743 Pleasanton Ave., Pleasanton	Pleasanton
Gallagher & Burk, Inc.	cr.	344 High St., Oakland	Oakland
Goddard Bros.	cr.	187 Sunset Blvd., Hayward	Hayward
Henry J. Kaiser Co.	s & g, cr	Kaiser Bldg., 1924 Broadway, Oakland	Niles & Radum
Independent Construction Co.	cr.	741 50th Ave., Oakland	
Niles Quarry Co.	cr, fr	Box 507A, 4061 Highland Blvd., Niles	Niles
Niles Sand & Gravel Co.	s & g	P.O. Box 155, Niles	Niles
Pacific Cement & Aggregates, Inc.	s & g, cr	400 Alabama St., San Francisco	Eliot, Fremont, Niles
Rhodes & Jamieson, Ltd.	s & g	333 23d Ave., Oakland	Centerville
San Leandro Rock Co.	cr	1575 Chabot Rd., San Leandro	San Leandro
H. C. Thompson Sand Dredging Co.	s	P.O. Box 403, Alameda	Alameda
A. C. Zaro Gravel Pit	s & g	301 Augustine St., Pleasanton	Pleasanton
Amador County:			
Harvey T. Kreth	cr	Ione	Ione
Owens-Illinois Glass Co.	gs	P.O. Box 1035, Toledo 1, Ohio	Ione
Sierra Sand & Gravel Co	s & g	Jackson	Sutter Creek
Butte County:			
Butte Creek Rock Co.	s & g	P.O. Box 512, Chico	Chico
Farr Bros.	s & g	P.O. Box 146, Gridley	Gridley
Henry J. Kaiser Co.	s & g	Kaiser Bldg., 1924 Broadway, Oakland	Oroville
Marler & Sons Rock Co.	s & g	4640 Virginia Ave., Oroville	Oroville
A. J. Mastellotto	s & g	136 Canyon Highway Dr., Oroville	Gridley
Mathews Readymix, Inc.	s & g	Rt. 1, Box 23, Gridley	Gridley
Oroville Rock & Sand Co.	s & g	Marysville Rd., Oroville	Oroville
Pentz Gravel	s & g	Durham	Durham
Perry & Rowe	s & g	P.O. Box 297, Live Oak	Biggs

Sand, Gravel, and Stone, Miscellaneous—Continued

Operator	Products	Address	Location
Calaveras County:			
Beerman & Jones	s & g	P.O. Box 698, Sonora	Angels Camp
Frederickson Bros.	s & g	1259 65th St., Emeryville	
Neilsen Gravel Plant	s & g	P.O. Box 457, San Andreas	Mokelumne Hill
Colusa County:			
Baldwin Construction Co.	s & g	P.O. Box 311, Marysville	
Cortina Rock, Sand & Gravel c/o Gene Godon	s & g	P.O. Box 357, Colusa	Colusa
Paul Entremont	s & g	P.O. Box 208, Colusa	Colusa
Harms Bros.	s & g	5261 Stockton Blvd., Sacramento	
Contra Costa County:			
Blake Bros.	cr	P.O. Box 1002, Richmond	Richmond
Gallagher & Burk Inc.	cr	344 High St., Oakland	Walnut Creek
Henry J. Kaiser Co.	cr	Kaiser Bldg., 1924 Broadway, Oakland	Clayton
Charles Law	s & g	585 Risdon Rd., Concord	Cowell
Marchio Silica Co.	s, fs	Rt. 1, Box 1386, Antioch	Antioch
William G. McCullough	s	220 Ninth St., Antioch	Antioch
Pacific Cement & Aggregates, Inc.	cr	400 Alabama St., San Francisco	Clayton
Serra Bros.	cr	R.F.D. 1, Box 355, Martinez	Pacheco
Silver Sand Co.	s	P.O. Box 5, Cowell	Cowell
Tunnel Rock Co.	cr	220 Tunnel Rd., Orinda	Orinda
Fay Wills	s	Rt. 1, Box 233, Antioch	Antioch
Del Norte County:			
Anne Chapman	s & g	P.O. Box 2162, Klamath	Klamath
Peter Kiewit Sons Co.	cr	P.O. Box 531, Vancouver, Wash.	
Rodney Creek Crusher Co.	cr	Smith River	Smith River
Simonson Lumber Co.	cr	Smith River	Smith River
Simpson Redwood Co.	s & g	Box A, Klamath	Klamath
Martin Tryon	s & g	P.O. Box 36, Fort Dick	Fort Dick
El Dorado County:			
California Rock & Gravel Co.	cr	1800 Hobart Bldg., San Francisco	Cool
Cold Springs Sand & Gravel Co.	s & g	57 Coloma St., Placerville	Placerville
Diamond Springs Lime Co.	cr	Diamond Springs, P.O. Box 409	Diamond Springs
El Dorado Limestone Co.	cr	Shingle Springs	Shingle Springs
Erwin A. Goltz, Estate	s & g	Rt. 3, Box 636, Placerville	Placerville
Harms Bros.	s & g	5261 Stockton Blvd., Sacramento	
J. T. White Contractors	s & g	P.O. Box 24, Lake Tahoe	Lake Tahoe

Fresno County:			
Anderson Rock Products	s & g	Old Lanesbridge, Fresno	Friant
Atchison, Topeka & Santa Fe Ry.	cr	121 E. Sixth St., Los Angeles	
Central Rock & Sand Co.	s & g	P.O. Box 425, Sanger	Sanger
L. D. Folsom	s & g	P.O. Box 347, Coalinga	Coalinga
Herndon Rock Products Co.	s & g	410 Thorn St., P.O. Box 886, Fresno	Fresno
Oilfield Transit Co. & Phoenix Construction Co.	cr	Bakersfield	
Pacific Cement & Aggregates, Inc.	s & g	400 Alabama St., San Francisco	Rockfield, Friant
Sanger Rock and Sand	s & g	17125 Kings Canyon Rd., Sanger	Sanger
Thompson Materials & Const. Co.	s & g	917 Dome St., Avenal	Coalinga
Volpa Bros.	s & g	233 Neilsen St., Fresno	
Paul E. Wood	s & g	2203 N. Friant St., Fresno	Mendota
Glenn County:			
Wm. Dunlap	s & g	County Rd., M. M. Willows	
E. B. Estes	s & g	Princeton	Princeton
Harms Bros.	s & g	5261 Stockton Blvd., Sacramento	
Orland Sand & Gravel Co.	s & g	P.O. Box 916, Orland	Wyo
Frank Reager	s & g	Glenn	Glenn
Kingman Reynolds	s & g	Newville Rd., Elk Creek	Elk Creek
Southern Pacific Co.	s & g	65 Market St., San Francisco	Wyo
Humboldt County:			
C. & C. Construction Co.	s & g	Alton	Alton
Eureka Sand & Gravel Co.	s & g	1955 Hittiker Ave., Eureka	Eureka
Tom Hull	rr	930 Carson St., Eureka	Blue Lake
McWhorter & Dougherty	s & g, b	P.O. Box 512, Fortuna	Fortuna
Mercer Fraser Co.	s & g, cr	Second & Commerical Sts., Eureka	Essex & Fernbridge
Railroad Construction Co.	s & g	Eureka	
Imperial County:			
Henry Aberta	s & g	1268 El Dorado, El Centro	Brawley
Farmers Gravel Co.	s & g	18404 Gothard St., Huntington Beach	Westmorland
H. C. Gibson	s & g	Box 1278, Brawley	Brawley
Inland Materials Co.	s & g	P.O. Box 1024, El Centro	Holtville
Janney Sand & Gravel	s & g	1886 Walnut St., Yuma, Arizona	Winterhaven
J. L. McElvany	s & g	P.O. Box 818, El Centro	El Centro
Nelson Gravel Pit	s & g	Holtville	Holtville
P. T. Pinner & Son	s & g	P.O. Box 115, Brawley	Brawley
J. B. Stringfellow	cr	P.O. Box 6, Riverside	
Valley Transit Cement Co.	s & g	P.O. Box 1489, El Centro	Brawley
Inyo County:			
Bishop Engineer & Const. Co.	s & g	P.O. Box 505, Bishop	Bishop
I. L. Croft & Son	s & g	P.O. Box 428, Saugus	
Gladding, McBean & Co.	g	2901 Los Feliz Blvd., Los Angeles	

Sand, Gravel, and Stone, Miscellaneous—Continued

Operator	Products	Address	Location
Kern County:			
Bacon Construction Co.	s & g	Inyokern	Inyokern
Dicco Inc.	s & g	Bin 217, Sta. A, Bakersfield	Bakersfield
Edison Sand Co.	s	118 34th St., Bakersfield	Bakersfield
Griffith Co.	cr	Box 175, Sta. B, Bakersfield	Bakersfield
Groover Mining & Milling Co.	rg	11620 Laurel Crest Dr., Studio City	
Willis B. Grossardt	s & g	430 Robertson Rd., Ridgecrest	Inyokern
Harms Bros.	s & g	5261 Stockton Blvd., Sacramento	
Hartman Concrete Materials Co.	s & g	P.O. Box 1632, Bakersfield	Bakersfield & Maricopa
Kern River Rock, Inc.	s & g	P.O. Box 65, Oildale	Oildale
Kern Rock Co.	s & g	P.O. Box 1697, Bakersfield	Bakersfield
Phoenix Construction Co.	s & g	1601 S. Union Ave., Bakersfield	Bakersfield
Triangle Rock Co.	s & g	Ridgecrest	Ridgecrest
Webster Sand Co.	s	P.O. Box 271, Bakersfield	Bakersfield
Kings County:			
Volpa Bros.	s & g	233 Neilsen St., Fresno	
Lake County:			
Cache Creek Gravel Co.	s & g	Box 597, Clearlake Highlands	Clearlake Highlands
F. M. Frazell	s & g	P.O. Box 914, Lakeport	Kelseyville
Marion Gheislen	s & g	Clearlake Oaks	Clearlake Oaks
Rodger E. Hellgren	s & g	P.O. Box 420, Clearlake Highlands	Clearlake Highlands
Lang Bros.	s & g	P.O.Box 66, Lakeport	Lakeport
Lassen County:			
Grayson Concrete Materials	s & g	1512 Fourth St., Susanville	Susanville
Harms Bros.	s & g	5261 Stockton Blvd., Sacramento	Susanville
George E. Miller	s & g	111 Morrill Ave., Reno, Nevada	
Lester L. Rice & Sons	s & g	P.O. Box 408, Yuba City	Adin
Susanville Marble & Granite Works	curbing	918 Nevada St., Susanville	Susanville
Los Angeles County:			
A. & H. Granite Co.	dg	1534 Broadway, Burbank	Burbank
Arrow Rock Co.	s & g	11670 Wicks St., Sun Valley	Sun Valley and Monrovia
Arrow Sand & Gravel Co.	s & g	P.O. Box 75, Palmdale	Palmdale
Azusa Rock & Sand Co.	s & g	P.O. Box 575, Azusa	Azusa
Bill & Rudy's Sand & Gravel	s & g	P.O. Box 1096, Walteria	Walteria
Blue Diamond Corp., Ltd.	s & g	1650 S. Alameda St., Los Angeles 54	El Monte, Sun Valley and Palmdale
Wm. J. Bonfield	dg	2008 Laurel Canyon Rd., Los Angeles 16	Sun Valley

C. & R. Sand Co.	s	3467 Greenfield Ave., Los Angeles 34	El Segundo
California Materials Co.	cr	P.O. Box 110, Whittier	Whittier
Caswell & Co.	ms	2357 E. Slauson Ave., Los Anglees 50	Torrance
Century Rock Products	s & g	360 W. Washington, Pasadena	Arcadia
Chandler's Palos Verdes Sand & Gravel	s & g	P.O. Box 295, Lomita	Lomita
Connolly-Pacific Co.	rr, cr	1925 Water St., Long Beach	Catalina Island
Consolidated Rock Products Co.	s & g, cr	Box 2950, Terminal Annex, or 2730 S. Alameda St., Los Angeles 54	Los Angeles, Azusa, Roscoe, Monrovia, Sun Valley, and North Hollywood
Robert Cox	fs	1975 Lundy Ave., Pasadena	Pasadena
John M. Ferry	s & g	5201 San Fernando Rd., Glendale 3	Littlerock
Gordon Sand Co.	ms, bs	P.O. Box 128, El Segundo	Inglewood
Graham Bros., Inc.	s & g, cr	5500 N. Peck Rd., El Monte	El Monte
Granite Materials	s & g, dg	12455 Wicks St., North Hollywood	Sun Valley
Peter Kiewit Sons Co.	s & g	345 Kieway Ave., Arcadia	Littlerock
Lindauer Corp.	s & g	Box 337, La Habra	La Habra
Livingston Rock & Gravel Co.	s & g, rr. cr	3366 Cherry Ave., Long Beach 7	Azusa, Sunland
Los Angeles Decomposed Granite Co.	dg	P.O. Box 39, Montebello	Montebello
McCaslin Materials Co.	rr	701 Foothill Blvd., Arcadia	Arcadia
McIlroy Blastsand Co.	bs	115 Nevada St., El Segundo	El Segundo
Manning Bros. Rock & Sand Co.	s & g, cr	P.O. Box C, Irwindale	Irwindale
Miller Bros. Truck Co.	ms	3451 Randolph St., Huntington Park	Redondo Beach. Torrance
Owl Rock Products Co.	dg	P.O. Box 509, Compton	Monrovia
Pacific Rock & Gravel Co.	s & g, dg	Box 778, Arcadia	Monrovia
Paramount Sand Co.	bs	1617 El Segundo, El Segundo	El Segundo
Saugus Sand & Gravel Co.	s & g	17125 E. Kings Canyon Rd., Saugus	Saugus
Edward Sidebotham & Sons	s & g	751 E. L St., Wilmington	Lomita
Sierra Rock Products	s & g	P.O. Box 125, Artesia	Monrovia
Sparks & Mundo Engineering Co.	s & g	1711 S. Soto St., Los Angeles 23	Monrovia
Terminal Rock & Sand	s & g	6851 East Ave., Littlerock	Littlerock
Torrance Sand & Gravel Products	s & g	25701 Crenshaw Blvd., Torrance	Torrance
Transit Mix Concrete Co.	s & g	3464 E. Foothill Blvd., Pasadena 8	Littlerock. Palmdale
C. B. Tuttle	s & g	3551 E. Sausalito, Los Alamitos	
West Coast Aggregates Corp.	s & g	P.O. Box 341, Pomona	Claremont
Madera County:			
Herndon Rock Products	s & g	P.O. Box 886, Fresno 14	Herndon
San Joaquin Valley Pipe Co.	s & g	P.O. Box 215, Chowchilla	Chowchilla
Thompson Materials & Construction Co., Inc.	s & g	917 Dome St., Avenal	Madera
Valley Feed & Fuel Co.	s & g	121 N. F St., Madera	Madera
Marin County:			
Black Point Aggregates, Inc.	s & g	c/o Niles Sand & Gravel, P.O. Box 155, Niles	Black Point
Basalt Rock Co.	cr, rr, s & g	Eighth and Rivers Sts., Napa	McNear Point
Hein Bros. Basalt Rock	cr	P.O. Box 162, Petaluma	
Hutchinson Co.	cr, m, r, rr	7360 Schmidt Lane, El Cerrito	San Rafael
Marin Rock & Asphalt Ind.	cr	P.O. Box 325, Novato	

Sand, Gravel, and Stone, Miscellaneous—Continued

Operator	Products	Address	Location
Mariposa County:			
Baun Construction Co., Inc.	s & g	3329 W. Dulley Ave., Fresno	Mariposa
Formation Logging Service Co.	cr	3434 W. 43d St., Los Angeles	
Mariposa Sand & Gravel Co.	s & g	Box N, Mariposa	Mariposa
Save, Sr., Wm. J.	s & g	P.O. Box 60, Mariposa	Mariposa
Mendocino County:			
Baxman, E. F.	s & g	Rt. 1, Box 248, Fort Bragg	Fort Bragg
Ellison Gravel Co.	s & g	122 Harold St., Fort Bragg	
Frost & Fitzhugh	s & g	Willits	Willits
C. A. Haun & Sons Gravel Co.	s & g	Rt. 1, Box 105, Willits	Willits
Hans W. Hoyer	s & g	P.O. Box 7, Cummings	Leggett
Peter Persico	s & g	P.O. Box 516, Willits	Willits
Ukiah Gravel & Cement Co.	s & g	P.O. Box 187, Ukiah	Ukiah
Warren S. Woodruff	s & g	Laytonville	Laytonville
Merced County:			
Fredricksen & Kosler	s & g	P.O. Box 398, Woodland Hills	Le Grand
Le Grand Sand & Gravel. c/o Hammer Bros.	s & g	P.O. Box 232 Le Grand	Le Grand
Los Banos Gravel Co.	s & g	P.O. Box 1111, Los Banos	Los Banos
Ray Richardson	s & g	1224 Nevada, Los Banos	Los Banos
River Rock, Inc.	s & g	20 E. 15th St., Merced	Atwater and Snelling
M. J. Ruddy & Sons (Santa Fe Rock & Sand)		Rt. 6, Box 1419A, Modesto	
Turlock Rock Co.	s & g	P.O. Box 548, Turlock	Balico
Valley Aggregates, Inc.	s & g	P.O. Box 744, Merced	Cressey
Modoc County:			
Baldwin Construction Co., Inc.	s & g	P.O. Box 311, Marysville	
Great Northern R. R. Co.	s & g	679 Market St., San Francisco	Mammoth
Harms Bros.	s & g	5261 Stockton Blvd., Sacramento	
Moyer Gravel Co.	s & g	P.O. Box 25, Alturas	Alturas
Mono County:			
Rice Bros., Inc.	s & g	P.O. Box 480, Lodi	
Monterey County:			
Max Cazin	s & g	Box 9, Metz Rd., King City	King City
Clementina, Ltd.	s & g	Seaside	Seaside
Del Monte Properties Co.	s & g, ms, dg	P.O. Box 150, Pacific Grove	Pacific Grove

Owens-Illinois Glass Co.	gs	P.O. Box 1035, Toledo, Ohio	Pacific Grove
Monterey Sand Co.	s & g, fs	Box 928, Monterey	Seaside
Pacific Cement & Aggregates, Inc.	s & g	400 Alabama St., San Francisco	Lapis and Prattco
Porter Marguard	cr	Rancho Canada	
Volpa Bros.	s & g	233 Neilsen St., Fresno 6	
Napa County:			
Basalt Rock Co.	cr, m, rr, s & g	Eighth and Rivers Sts., Napa	Napa
Benson Gravel Plant	s & g	P.O. Box 341, Angwin	Pope Valley
R. A. Farich Co.	s & g	P.O. Box 307, Stockton	Linda
Fredrickson Bros.	cr	1259 65th St., Emeryville	
Nevada County:			
Baldwin Construction Co., Inc.	s & g	P.O. Box 311, Marysville	
A. O. & K. M. Hansen	s & g	Rt. 1, Box 472-L, Grass Valley	Grass Valley
M. J. Ruddy & Sons	s & g	Rt. 6, Box 1419A, Modesto	
Robert P. Winkle	s & g	Rt. 2, Box 2256, Grass Valley	Grass Valley
Orange County:			
L. P. Arnold	s	7655 E. Second St., Downey	Santa Ana
Burris Sand Pit, Bessie M. Calhoun	s	Box 1741, Santa Ana	Anaheim
California Rock Co.	s & g	12111 S. Yorba, Orange	Orange
Consolidated Rock Products Co.	s & g, cr, m, b, r, rr, etc.	2730 S. Alameda St., Los Angeles 54	Fullerton & Orange
Foster Sand & Gravel	s & g	915 S. Spadra Rd., Fullerton	Orange
V. J. Frye	ms	1901 N. Olive St., Santa Ana	Newport Beach
Graham Bros., Inc.	s & g, cr, m, b, r, rr, etc.	5500 N. Peck Rd., El Monte	San Juan Capistrano
D. D. Lawhead & Sons	dg	111 14th St., Seal Beach	Buena Park
Longsdon Sand Plant	s	12261 E. Chapman Ave., Anaheim	Anaheim
McClellan & Sons	s	151 Commercial Way, Costa Mesa	Anaheim
Miller Bros. Trucking Co.	ms	3451 Randolph St., Huntington Park	Santa Ana
R. J. Noble Co.	s & g	P.O. Box 620, Orange	Orange
Orange County Rock Producers	s & g	P.O. Box 125, Artesia	Artesia
James Sparkes Sand Pit	s	P.O. Box 589, Anaheim	Anaheim
Star Rock Products	s & g	360 W. Washington St., Pasadena	Anaheim
Sully-Miller Construction Co.	s & g, cr	P.O. Box 432, Orange	El Modena
Placer County:			
M. J. Ruddy & Son	s & g	Rt. 6, Box 1419A, Modesto	
Union Granite	cr	P.O. Box 819, Rockland	Rockland
Plumas County:			
Western Pacific R.R.	cr	526 Mission St., San Francisco	

Sand, Gravel, and Stone, Miscellaneous—Continued

Operator	Products	Address	Location
Riverside County:			
A. T. & S. F. Ry. Co.	b	121 E. Sixth St., Los Angeles 14	Box Springs
Guy Atkinson Co.	cr, fr	P.O. Box 259, Long Beach	
Baun Construction Co., Ltd.	s & g	P.O. Box 4057, Fresno	
Haven Granite Corp.	pg	890 S. Arroyo Parkway, Pasadena 2	Riverside
W. E. Kier Construction Co.	s & g	2323 E. Rosecrans, El Segundo	Bertha
Massey Rock & Sand Co.	s & g	Box 695, Indio	Indio
Minnesota Mining & Mfg. Co.	rg	900 Fauquier Ave., St. Paul 6, Minn.	Corona
Owens-Illinois Glass Co.	gs	P.O. Box 1035, Toledo 1, Ohio	Corona
Palm Springs Builders Supply Co.	s & g	490 Sunny Dunes Rd., Palm Springs	Whitewater
San Gorgonio Rock Products	s & g	1990 N. Hargrove St., Banning	Banning
J. B. Stringfellow	cr, rr	P.O. Box 6, Riverside	Riverside
Transit Mixed Concrete Co.	s & g	3464 E. Foothill Blvd., Pasadena	Corona
Valley Rock & Sand Corp.	s & g	P.O. Box 926, San Jacinto	Moreno
Sacramento County:			
Brighton Sand and Gravel Co.	s & g	P.O. Box 1, Perkins	Perkins
Del Paso Rock Products Co.	s & g	3490 Fair Oaks Blvd., Sacramento	Del Paso
Fair Oaks Gravel Co.	s & g	4000 Illinois Ave., Fair Oaks 19	Fair Oaks
Haggin Gravel Co.	s & g	P.O. Box 1072, Sacramento	Sacramento
Hard Materials Co.	ms	12th & Vine Sts., Sacramento	Sacramento
Harms Bros.	s & g	5261 Stockton Blvd., Sacramento	
McGillivray Construction Co.	s & g	P.O. Box 873, Sacramento	Sacramento
Pacific Cement & Aggregates, Inc.	s & g, cr, m, b, r, rr, etc.	400 Alabama St., San Francisco	Fair Oaks, Prattrock, and American River
Robert Powell Products	s	P.O. Box 1412, Sacramento	Sacramento
Robertson Sand & Gravel Co.	s & g	1061 Vine St., Sacramento	Sacramento
A. Teichert & Son, Inc.	s & g	P.O. Box 928, Sacramento 4	Perkins
San Benito County:			
Granite Rock Co.	cr, m, b	Box 151, Watsonville	Logan
San Bernardino County:			
Atchison, Topeka, and Santa Fe Railway Co.	cr	121 E. Sixth St., Los Angeles 14	Box Springs
Barstow Rock & Gravel Co.	s & g	P.O. Box 808, Barstow	Barstow
Base Rock Co., Inc.	s & g	P. O. Box 107, Claremont	North Claremont
Baun Construction Co.	s & g	3329 W. Dudley Ave., Fresno	Victorville
Brubaker-Mann Co.	rg	R.F.D. 1, Barstow	Barstow
Central Rock Co.	s & g	1465 E. 16th St., Upland	Upland
Consolidated Rock Products Co.	s & g, cr, m, b, r, rr, etc.	2730 S. Alameda St., Los Angeles	Claremont

Dana Materials Co.	s & g	P.O. Box 187, Apple Valley	Daggett
Daniel & Dixon Co., Inc.	s & g	P.O. Box 134, Cross Roads	Earp
Frank Day & Co.	s & g	P.O. Box 264, Big Bear Lake	Big Bear Lake
Fourth St., Rock Crusher	s & g	P.O. Box 469, San Bernardino	San Bernardino
Hanawalts	s & g	4594 San Bernardino Ave., Ontario	Pomona
Holliday Rock Products Co.	s & g	P.O. Box 496, Colton	Upland & Colton
Mineral Materials	cr	1145 Westminister Ave., Alhambra	
Owl Materials Co.	s & g	P.O. Box 307, Riverside	Colton
Rainbow Rock, Inc.	rg	P.O. Box 306, Barstow	Barstow
Riverside Cement Co.	cr	621 S. Hope St., Los Angeles 17	Oro Grande
San Bernardino Rock & Gravel Co.	s & g	1910 W. Seventh St., San Bernardino	San Bernardino
W. J. Smithson & Son	cr	Box 28, Big Bear Lake	
Southern Calif. Mineral Co.	cr	320 S. Mission Rd., Los Angeles 33	
Triangle Rock & Gravel Co.	s & g	P.O. Box 2098, San Bernardino	San Bernardino
Tri-City Rock Co.	s & g	P.O. Box 672, Redlands	Redlands
Union Pacific Railroad Co.	s & g, b	1416 Dodge St., Omaha 2, Neb.	Baxter
San Diego County:			
American Sand Co.	ms, bs	P.O. Box 5326, San Diego 5	San Diego
Beeler Canyon Sand & Gravel Co.	s & g	Hollydale, Calif.	Hollydale
Canyon Rock Co.	s & g, cr	P.O. Box 3158, Hillcrest Sta., San Diego	San Diego
Caudell & Johnson	s & g	P.O. Box 3098, Hillcrest Sta., San Diego	Mission Valley
Crystal Silica Co.	s & g, fs	Box 180, Los Angeles 1	Oceanside
W. R. Dennis Construction Co.	s & g, cr	P.O. Box 3158, Hillcrest Sta., San Diego 3	San Diego
Denton's Sand Plant, Edmond Denton	s & g	4111 Poplar St., San Diego	El Cajon
Einer Bros., Inc	s	P.O. Box 936, Escondido	Escondido
El Cajon Sand & Gravel Co.	s & g	640 Marshall St., El Cajon	El Cajon
H. G. Fenton Material Co., Inc.	s & g	1245 National Ave., San Diego 12	San Diego
Kenneth H. Golden Co., Inc.	dg	1367 Sixth Ave., San Diego	Graniteville
M. H. Golden Construction Co.	dg	Mission Gorge Rd., Box 891, San Diego 10	San Diego
Gross Sand Co.	s	Gen. Del., Lakeside	Lakeside
C. R. Guthridge Sand Plant	s	Rt. 1, Box 52, Del Mar	Del Mar
Mission Sand Plant	s	P.O. Box 894, Rt. 1, San Diego 10	San Diego
Monarch Materials Co.	s & g	P.O. Box 64, San Diego 12	San Diego
Nelson & Sloan	sg & cr	Seventh and Main Sts., Otay	Chula Vista
Carl Niemann	s & g	Box 52, Del Mar	Rancho Santa Fe
H. W. Rohl Co., Inc.	s & g	P.O. Box 28, Oceanside	Oceanside
Sierra Sand Co.	s	Rt. 2, Box 1095, Lakeside	Lakeside
Smith Construction Co.	s & g	P.O. Box 247, Cardiff by the Sea	Rancho Santa Fe
Woodward Sand Co., Arthur C. Woodward	s & g	2914 Bancroft St., San Diego 4	San Diego
San Francisco County:			
Charles L. Harney, Inc.	cr	575 Berry St., San Francisco 7	San Francisco

Sand, Gravel, and Stone, Miscellaneous—Continued

Operator	Products	Address	Location
San Joaquin County:			
R. A. Farish Co.	s & g	P.O. Box 307, Stockton	Linden
S. M. McGaw Co.	s & g	307 Elks Bldg., Stockton, Box 767	Linden
Nomellini & Funk	s & g	P.O. Box 1528, Stockton	
Pacific Cement & Aggregates, Inc.	s & g	400 Alabama St., San Francisco 10	Tracy
Putman Sand & Gravel Co., Inc.	s & g	200 Santa Rosa Ave., Modesto	
Rice Bros., Inc.	s & g	P.O. Box 480, Lodi	Clements
A. Teichert & Son, Inc.	s & g	P.O. Box 928, Sacramento	Tracy
Claude C. Wood Co.	s & g	P.O. Box 599, Lodi	Clements
San Luis Obispo County:			
Great Lakes Carbon Corp.	cr	612 S. Flower St., Los Angeles 17	Bradley
Guiton Foundry Supply	ms	P.O. Box 258, Oceano	Oceano
Morro Rock & Sand	s & g	P.O. Box 694, Morro Bay	Cambria
Walter B. Roselip Co.	s & g	Box 458, Atascadero	Atascadero
Jack Webster	s & g	955 Grand Ave., Arroyo Grande	
Wilson Rock & Gravel	s & g	P.O. Box 119, Grover City	
San Mateo County:			
J. O. Archibald	dg	P.O. Box 968, Redwood City	
Lowrie Paving Co.	cr	1755 Evans Ave., San Francisco	
Marks Materials, Inc.	cr	P.O. Box 806, Belmont	Rockaway Beach
McCammon-Wunderlick	cr	P.O. Box 359, Palo Alto	
Pacific Cement & Aggregates, Inc.	cr, s	400 Alabama St., San Francisco	Brisbane & Junipero Serra Blvd.
Rockaway Quarry, Inc.	s	400 Montgomery St., San Francisco	Rockaway Beach
Skyline Materials, Inc.	cr	P.O. Box 806, Belmont	Belmont
Smith, L. C.	dg	225 19th Ave., San Mateo	
Santa Barbara County:			
Fredrickson & Wilson Const. Co.	s & g	873 81st St., Oakland	
Rancho Grande Lands Inc.	s & g	P.O. Box 212, Solvang	Solvang
Southern Pacific Milling Co.	s & g	P.O. Box 491, Ventura	Santa Maria
Valley Rock & Sand Co.	s & g	218 S. "L" St., Lompoc	Santa Ynez
Santa Clara County:			
Bahr & Ledoyen, Inc.	cr	3291 Park Blvd., Palo Alto	Los Altos
J. C. Bateman, Inc.	s & g	650 Stockton Ave., San Jose	San Jose
Bren's Gravel & Sand	s & g, fr	211 Princeville St., Gilroy	Gilroy
Edward Keeble	cr	Tully Rd., San Jose	
Los Gatos Sand and Gravel Co.	s & g	P.O. Box 502, Los Gatos	Los Gatos
Mirassou Bros.	cr	15630 Harwood Rd., Los Gatos	Los Gatos

Neary Rock Quarry Inc.	s & g, cr	11920 Stonebrook Rd., Los Altos	Los Gatos
Pacific Cement & Aggregate, Inc.	s & g	400 Alabama St., San Francisco	Coyote
Leo F. Piazza Paving Co.	s & g	Rt. 1, Box 800, San Jose	San Jose
A. J. Raisch Paving Co.	s & g	900 W. San Carlos St., San Jose	San Jose
Reed & Graham Inc.	s & g	690 Sunol, San Jose	
Renz Construction Co.	cr		
Sondgrath Bros.	cr	P.O. Box 1055, Mountain View	Los Altos
Volpa Bros.	s & g	233 Neilsen, Fresno 6	
A. Voss	s & g	10445 Stevens Rd., Cupertino	Stevens Creek
Western Gravel Corp.	s & g	P.O. Box 1026, Campbell	Campbell
Western Tile & Supply Co.	s & g	P.O. Box 104, Gilroy	Gilroy
Santa Cruz County:			
Concrete Service Co.	s & g	160 Sunol St., San Jose	Scotts Valley
Graham & Son	s & g	500 Mt. Hermon Rd., Santa Cruz	Santa Cruz
Hansen, Silvey & Sinnot	cr	P.O. Box 375, Felton	Felton
Henry J. Kaiser Co.	s	1924 Broadway, Oakland	Olympia, Felton
V. W. Maddock	cr	P.O. Box 177, Soquel	Soquel
Pacific Cement & Aggregate, Inc.	s	400 Alabama St., San Francisco	Felton
Santa Cruz Aggregate Co.	s & g	646 Lockhart Gulch Rd., Santa Cruz	Felton & Olympia
United Bldrs. & Farmers Supply	s & g	P.O. Box 96, Soquel	Soquel
Shasta County:			
Fredrickson & Watson Const. Co.	s & g	873 81st St., Oakland	Anderson
J. H. Hein Co.	s & g	P.O. Box 226, Redding	Redding
Leland Kerns	s & g	Gazelle	Gazelle
Lassen Sand & Gravel	s & g	Burney	Burney
Oaks Sand, Gravel & Cement Products	s & g	P.O. Box 1847, Redding	Redding
Redding Sand & Gravel, Inc.	s & g	P.O. Box 741, Redding	Redding
Riley Trucking Co.	s & g	P.O. Box 1462, Redding	Redding
A. G. Valentine	s & g	Burney	Burney
Siskiyou County:			
Clements Construction	s & g	P.O. Box 321, Hayward	Tulelake, Fort Jones
S. G. Herrington	s & g		Yreka
Peter Kiewit & Son	s & g	P.O. Box 531, Vancouver, Wash.	Fort Jones
Mt. Shasta Gravel Co.	s & g	P.O. Box 836, Mt. Shasta	Mt. Shasta
William Tregombo	cr	P.O. Box 829, Redding	
Solano County:			
Asta Construction Co.	s & g	P.O. Box 758, Rio Vista	Rio Vista
Delta Construction Co.	s & g	P.O. Box 457, Rio Vista	Rio Vista
Fredrickson Bros.	cr, fr	1257 65th St., Emeryville	
Henry J. Kaiser Co.	s	1924 Broadway, Oakland	
Peter Kiewit & Parish Bros.	s & g	1205 E. Second St., Benicia	
J. M. Nelson, Cordelia quarry	cr, rr	Rt. 1, Suisun	Cordelia
Parish Bros.	cr, rr, s & g	1205 E. Second St., Benicia	Benicia
Solano Excavator	cr	130 E. "O" St., Benicia	

Sand, Gravel, and Stone, Miscellaneous—Continued

Operator	Products	Address	Location
Sonoma County:			
Joe Artega	cr	550 E. Cotati Ave., Cotati	Cotati
Basalt Rock Co.	s & g, cr, rr	P.O. Box 5401, Eighth and Rivers Sts., Napa	Healdsburg
Construction Supply Co.	s & g	1330 King St., Santa Rosa	Santa Rosa, Mirabel
Empire Rock Co., Inc.	s & g	3851 E. Montgomery Dr., Santa Rosa	Santa Rosa
Ben Gerrick Co.	cr	Petaluma	
Thomas A. Graham	cr, m	Box 1, Occidental	Occidental
Hein Bros. Basalt Rock Co.. Mark Hein, Pres.	s & g, cr, m, b	P.O. Box 162, Petaluma	Petaluma, Windsor
Parish Bros. Inc.	cr	1205 Second St., Benicia	Goodyear
St. Helena Stone	cr	St. Helena	
Talbert Rock Quarry	cs	P.O. Box 92, Cotati	Cotati
L. T. Willig	s & g	Jenner	
J. B. Wingate & Son	cr	585 Triniti Rd., Glen Ellen	Glen Ellen
Stanislaus County:			
American Sand & Gravel Co.	s & g	Ninth and M Sts., Modesto	Empire
Graystone Tile	s	316 River Rd., Modesto	Modesto
Hughson Gravel Plant	s & g	P.O. Box 35, Hughson	Hughson
Frank B. Marks, Jr.	s & g	P.O. Box 668, Newman	Newman
Modesto Sand and Gravel Co., Inc.	s & g	P.O. Box 496, Salida	Salida
George Reed	s & g	529 Covena Ave., Modesto	Waterford
M. J. Ruddy & Sons, Santa Fe Rock & Sand Br.	s & g	Rt. 6, Box 1419A, Modesto	Waterford, Oakdale
Standard Rock Co.	s & g	P.O. Box 696, Escalon	Escalon
Chas. D. Warner & Sons, Inc.	s & g	1027 Yosemite Blvd., Modesto	Hickman
Sutter County:			
Baldwin Construction Co.	s & g	P.O. Box 311, Marysville	
Basalt Rock Co.	s & g	P.O. Box 540, Napa	
Hutchinson Co.	s & g	7360 Schmidt Lane, El Cerrito	Yuba City
McGillivray Const. Co.	s & g	P.O. Box 873, Sacramento	Sheridan
Perry & Rowe	s & g	P.O. Box 297, Live Oak	Live Oak
Stineman Sand & Gravel	s & g	Rt. 1, Box 10, Wheatland	Wheatland
Tehama County:			
Allen & Reddy	s & g	Box 729, Red Bluff	Red Bluff
Globe Bldg., Supply, Inc.	s & g	P.O. Box 637, Concord	Richfield
Red Bluff Sand & Gravel Co.	s & g	P.O. Box 1847, Redding	Red Bluff

Trinity County:			
Arbuckle & Garrison	s & g	Box 148, Lewiston	Lewiston
Trinity Sand & Gravel Co.	s & g	Weaverville	Douglas City
Tulare County:			
Dacco Inc.	s & g	Bin 217, Sta. A, Bakersfield	
Middletons-Sequoia Rock Co.	s & g	P.O. Box 1468, Visalia	Porterville
Pacific Cement & Aggregate, Inc.	s & g	400 Alabama St., San Francisco	Lemon Cove
E. T. Quiram & Sons	s & g	407 Garden St., Porterville	Porterville
Paul E. Woof	s & g	2203 N. Fruit St., Fresno	Lemon Cove
Tuolumne County:			
Beerman & Jones	s & g, rr	P.O. Box 698, Sonora	Soulsbyville
A. P. Jones, Sierra Sand & Gravel	s & g	Jamestown, P.O. Box 504	Sonora
M. J. Ruddy & Sons	s & g	Rt. 6, Box 1419A, Modesto	
H. M. Stewart & V. S. Parthero	s & g	P.O. Box 8, Chinese Camp	Chinese Camp
Tri Dam Contractors	s & g	Beardsley Project, Strawberry	Strawberry
Ventura County:			
Independent Rock Co.	s & g	P.O. Box 181, Santa Paula	Santa Paula
Miller Bros. Truck Co.	ms	3451 Randolph St., Huntington Park	Ventura
Saticoy Rock Co.	s & g, cr, m	Box 970, Ventura	Saticoy-Ventura
So. Pac. Milling Co., Sta. Paula Rock Div.	s & g	P.O. Box 491, Ventura	El Rio, Montalvo, Santa Paula
Yolo County:			
Pacific Cement & Aggregates, Inc.	s & g	400 Alabama St., San Francisco	Yolo
Schwarzgruber & Sons	s & g	28 W. Main St., Woodland	Cache Creek
A. Teichert & Sons	s & g	P.O. Box 928, Sacramento 4	Woodland
Wood, Mrs. Lucy S.	s & g	915 First St., Woodland	Woodland
Yuba County:			
Baldwin Construction Co.	s & g	P.O. Box 311, Marysville	Marysville
Rice, Lester, & Son	s & g	P.O. Box 408, Yuba City	Marysville
Yuba River Sand Co.	s & g	Box 307, Marysville	Marysville

LEGEND

b—Ballast
bs—Blast sand
cr—Crushed rock
dg—Decomposed granite
fr—Fill rock
fs—Filter sand
g—Ganister
gs—Glass sand
m—Macadam
ms—Molding sand
pg—Poultry grit
r—Rubble
rg—Roofing
rr—Riprap
s—Sand
s & g—Sand and gravel

Silver

(Not less than 1,000 ozs. per year)

Mine	Type* of Mine	Operator	Address	Location
Amador County:				
Copper Hill	C	Fitzgerald, Smith & Aooc.	P.O. Box 586, Placerville	Plymouth
Inyo County:				
Christmas Gift, Lucky Jim, Promontory	L	Louis Warnker, Jr.	Lone Pine	Darwin-Coso
Darwin	L	The Anaconda Co.	P.O. Box 58, Darwin	Darwin
Defense	L	Foreman & Foreman	P.O. Box 175, Darwin	Modoc
Lippincott (Lead King)	K	Lippincott Lead Mines	P.O. Box 1811, Santa Ana	Ubehebe
Pine Creek	T	Union Carbide Nuclear Co.	30 E. 42d St., N. Y. 17	Bishop
Santa Rosa	L	Norris & Bracken	P.O. Box 111, Keeler	Keeler
Shoshone	L	The Anaconda Co.	P.O. Box 58, Darwin	Shoshone
Kern County:				
Burton Mill	U	Burton Bros., Inc.	Rosamond	Mojave
Silver Queen	S	Stoel, Jenkins & Wright	P.O. Box 415, Mojave	Mojave
Nevada County:				
Empire-North Star	G	Empire Star Mines Co., Ltd.	P.O. Box 1027, Grass Valley	Grass Valley
Sacramento County:				
Natomas Dredges	D	Natomas Co.	P.O. Box 1197, Sacramento	Natoma
San Bernardino County:				
Telegraph	S	Death Valley Panamint Mining Co.	P.O. Box 134, Baker	Baker
Shasta County:				
Afterthought	Z	M. D. Jordan	2852 Fowler Ave., Ogden, Utah	Ingot
Sierra County:				
Brush Creek	G	Best Mines Co., Inc.	P.O. Box 177, Downieville	Downieville
Siskiyou County:				
Siskon	G	Siskon Corp.	Box 148, Happy Camp	Happy Camp
Yuba County:				
Yuba	D	Yuba Consolidated Gold Fields	351 California St., San Francisco 4	Hammonton

LEGEND

C—copper mine
D—gold bucket-line dredge
G—gold lode mine
K—lead mine
L—lead-zinc mine
S—gold-silver mine
T—tungsten mine
U—clean up
Z—copper-zinc mine

Slate

Operator	Address	Location
El Dorado County:		
Kelsey Slate Co., Bill Powell (flagstone)	Box F, Kelsey	Kelsey
Pacific Minerals Co., Ltd., (granules, filler)	337 10th St., Richmond	Chili Bar
Mariposa County:		
Agua Fria Slate quarry	Mariposa	

Soda

Operator	Address	Location
Inyo County:		
Pittsburgh Plate Glass Co., Columbia Chemical Division (soda ash, trona)	Bartlett	Bartlett
Kern County:		
Pacific Coast Borax Co. (salt cake)	P.O. Box 9128, Sta. S, Los Angeles	Boron
San Bernardino County:		
American Potash & Chemical Corp. (soda ash, salt cake)	3030 W. Sixth St., Los Angeles 54	Trona
West End Chemical Division, Stauffer Chemical Co. (soda ash and salt cake)	1956 Webster St., Oakland 12	Westend

Stone, Dimension
(Other than granite)

Operator	Product	Address	Location
Colusa County:			
California Cut Stone & Granite Works	sandstone	Railroad Ave. at Magnolia, South San Francisco	Sites
El Dorado County:			
T. C. Nutt	volcanic tuff	P.O. Box 9, Placerville	Placerville
Sierra Placerite Corp.	volcanic tuff	Rt. 3, Box 252, Placerville	Placerville
Kern County:			
N. W. Sweetser	sandstone	P.O. Box 445, Rosamond	Rosamond
Los Angeles County:			
Robert Cox	miscellaneous stone	1975 Lundy Ave., Pasadena	Pasadena
Great Lakes Carbon Corp.	diatomaceous shale	612 S. Flower St., Los Angeles 17	Palos Verdes
H. A. Jones	quartz mica schist	215 W. Green St., Pasadena	Bouquet Canyon
Don Poteet	quartz mica schist	10947 Haddon Ave., Pacoima	Bouquet Canyon
Frank P. Raggio	quartz mica schist	Rt. 2, Box 353, Saugus	Saugus
Victor Williams	quartz mica schist	2605 Honolula Ave., Montrose	Bouquet Canyon
Mariposa County:			
Formation Logging Service Co.	miscellaneous stone	3434 W. 43d St., Los Angeles	
Monterey County:			
Porter-Marquard Carmel Stone quarry	indurated shale and sandstone	Rancho Canada, Carmel Valley	Carmel Valley
Riverside County:			
California Limestone Products Co.	miscellaneous stone	139 S. Beverly Dr., Beverly Hills	
J. W. Hannah Jr.	wollastonite	2131 N. California St., Stockton	
Lawrence Johnson	wollastonite	P.O. Box 821, Blythe	Blythe
San Bernardino County:			
W. C. Higdon, Marbolite quarry	miscellaneous stone	Box 12, Knotts Berry Farm, Buena Park	
San Diego County:			
Art Carlsen	sandstone	595 Mountain View Rd., La Cresta	La Cresta
San Luis Obispo County:			
Great Lakes Carbon Corp.	diatomaceous shale	612 S. Flower St., Los Angeles 17	Paso Robles

Santa Barbara County:			
G. Antolini & Sons	calcareous siltstone	131 E. Gutierrez St., Santa Barbara	Santa Maria
Santa Clara County:			
Mirassou Bros.	rhyolite	15630 Harwood Rd., Los Gatos	Lone Hill
Santa Cruz County:			
Pacific Limestone Products Co.	limestone	445 Spring St., Santa Cruz	Santa Cruz
Sonoma County:			
Paul Cabrol	volcanic tuff	190 Seaview, San Rafael	Glen Ellen
Cliff Reed	volcanic tuff	901 Triniti Rd., Glen Ellen	Glen Ellen
Saint Helena Stone Co.	volcanic tuff	P.O. Box 413, San Anselmo	Glen Ellen
J. B. Wingate & Son	volcanic tuff	585 Triniti Rd., Glen Ellen	Glen Ellen
Tuolumne County:			
Sonora Marble Aggregates	limestone	Rt. 1, Box 599, Sonora	Shaws Flat

Strontium Minerals

Operator	Address	Location
San Diego County:		
Pan Chemical Co.	3461 E. 26th St., Los Angeles	Fish Creek
San Bernardino County:		
Gene de Zan	605 G St., Bakersfield	Cady Mountains

Sulfur

Operator	Address	Location
Alpine County:		
Anaconda Co.	25 Broadway, New York 4, N. Y.	Markleeville

Talc, Soapstone and Pyrophyllite

Mine	Operator	Address	Location
El Dorado County:			
Harris	Frank Harris	Box 706, Shingle Springs	Latrobe
(soapstone)	Pacific Minerals Co.	337-10th St., Richmond	Shingle Springs
Inyo County:			
White Mountain (talc)	Wm. Bonham	P.O. Box 446, Lone Pine	Keeler
Big Talc and Warm Springs (talc)	Louise Grantham et al.	237 N. Second Ave., Upland	Shoshone
White Eagle (talc)	Huntley Industrial Minerals	P.O. Box 305, Bishop	Bigpine
Alliance (talc)	George W. Koest	P.O. Box 85, Darwin	Darwin
Eclipse (talc)	Kennedy Minerals Co., Inc.	2550 E. Olympic Blvd., Los Angeles 23	Tecopa
Death Valley (talc)	Multi Mines, Inc.	2550 E. Olympic Blvd., Los Angeles 23	Shoshone
Frisco, Eureka, Rogers, Talc City (talc)	Sierra Talc & Clay Co.	1608 Huntington Dr., South Pasadena	Keeler, Bigpine and Tecopa
	Fink and Adams	1406 Waterman St., San Bernardino	Tecopa
Mammoth	W. T. Norman		
Los Angeles County:			
Katz (soapstone)	Dr. Leon N. Katz	9837 Foothill Blvd., San Fernando	Acton
Mono County:			
Pacific (pyrophyllite)	Huntley Industrial Minerals, Inc.	P.O. Box 305, Bishop	Laws
San Bernardino County:			
BFJ	B.F.J. Mining Co.	237 N. Second Ave., Upland	
Omega, Victor	Pomona Tile Mfg. Co.	629 N. La Brea Ave., Los Angeles 36	Tecopa
Victor (pyrophyllite)	Mineral Materials Co.	1145 Westminister Ave., Alhambra	Victorville
Caliente, Ibex, Rainbow, Sheep Creek, Silver Lake, Addenda, Yucca Grove (talc)	Sierra Talc & Clay Co.	1608 Huntington Dr., South Pasadena	Shoshone and Baker
Acme, Arletta, Excelsior, Monarch, Panamint, and Superior (talc)	Southern California Minerals Co.	320 S. Mission Rd., Los Angeles 33	Shoshone and Baker
W. S. Skeoch (talc)	Western Talc Company	1901 E. Slauson Ave., Los Angeles	Tecopa
San Diego County:			
Pioneer (pyrophyllite)	Pioneer Pyrophyllite Producers	25701 Crenshaw Blvd., Torrance	Cardiff
Four Gee (pyrophyllite)	H. G. Golem	Rt. 1, Box 789, Escondido	Escondido
Harborlite (pyrophyllite)	Harborlite Corp.		Escondido

Tungsten

Mine	Operator	Address	Location
Alpine County:			
Alpine	C. B. Lovestedt	Box W, Gardnerville, Nevada	Woodfords
Alturas	C. B. Lovestedt	Box W, Gardnerville, Nevada	Woodfords
Granite	Brewer, George	Markleeville	Woodfords
Juniper	Bill Tholke		
Valpine	Imperial Operating Co.	Woodfords	Woodfords
Calaveras County:			
Moore Creek	Moore Creek Mining Co.	P.O. Box 78, Pioneer	Pioneer
El Dorado County:			
Last Hope	Sciaroni Bros.	Placerville	Placerville
Fresno County:			
Cal-Tex	Cal-Tex Tungsten Co.	P.O. Box 591, Odessa, Texas	Fresno
Donoho No. 3	Donoho Mining Co.	P.O. Box 15, Piedra	Sanger
Ha-Wo-Pa-Ty	F. E. Mittie and E. R. Fowler		Piedra
Hill Top	E. G. Peron	Trimmer Rt., Sanger	Sanger
Rabbits Foot	A. J. Peterson		Sanger
Jackpot	E. A. McMurty and A. Benson	Tollhouse	Tollhouse
Lucky Strike	Lucky Strike Mine		
Red Bud	Red Bud Mine	c/o Stadium Quick Service, P.O. Box 1292, Fresno	
Red Garnet	Ed Coons	1911 Mission St., Santa Cruz	Tollhouse
Rensselaer	J. W. Martin		Dinkey Creek
Rensselaer Wheelbarrows	R. W. Mine		
Sequoia	Sequoia Tungsten Mining Co.	9127 S. Mendocino St., Parlier	
Sheridan	Glenwood Sheridan, Kuigs River Mining Co.	20133 E. Trimmer Springs Rd., Sanger	
Inyo County:			
Adamson	Palmer & Decker	163 W. Line St., Bishop	Bishop
Albatross	Barney Miller	262 Academy St., Bishop	Bishop
B & M Shaft	California Tungsten M & M Co.		Death Valley
Big Shot	H. Stevens	Bishop	Bishop
Black Water	O. R. Mont-Eton	Box 4, Trona	Trona
Blue Cliff	California Tungsten M & M Co.	12881 Euclid Ave., Ontario	Trona
Brownstone	Brownstone Mining Co.	Box 396, Bishop	Bishop
Chipmunk	Alphonso Alt	387 Grove St., Bishop	Bishop
Custer	L. H. Buckner		
Durham	Ajax Tungsten Corp.	137 S. Main St., Bishop	Darwin

Tungsten—Continued

Mine	Operator	Address	Location
Inyo County—Continued			
Eagle Nest	Eagle Nest Mine		
El Diablo	Mr. Moore		Darwin
El Diablo Mill Tails	C. G. Scharf	524 N. Main, Bishop	W. Bishop
Fox Hale 1 and 2	C. O. Russell	Box 929, Bishop	
Green Hale	Don Beauregard	107 W. Pine St., Bishop	Bishop
Hanging Valley	Rom & Allison		Bishop
Hope	Don Byrnes	Bishop	Bishop
Jake	Jake Mining Co.	Box 1556, Trona	Trona
Johnny claims	K. G. Moore	Rt. 1, Box 162, Bishop	Bishop
Jumbo	R. G. Bradley and R. D. Horn	Round Valley	Independence
Keeler gold Millsite	J. Hilliard	Box 75, Keeler	Keeler
L & L	L. Brown	Box 674, Bishop	Bishop
Look Out	K. Moore	Rt. 1, Box 162, Bishop	Bishop
Lucky Buck	U. S. Tungsten Co.	736 Van Ness Ave., Fresno	Trona
Lucky Three	A. Vierra		Trona
Mariposa	O. Whitman	409 N. Fowler, Bishop	Bishop
Moonlight	Early, David & Stokes	Rt. 1, Box 198, Bishop	Bishop
Peterson	T. E. Makinen	Rt. 2, Box 418, Bishop	Bishop
Pine Creek	Union Carbide Nuclear Co.	30 E. 42d St., New York 17, N. Y.	Bishop
Poletta Red	A. G. Skiles	P.O. Box 196, Bishop	Bishop
R & S	Sooner Death Valley Mining Co.	Box 898, Trona	Trona
R & S	R & S Mining Co.	Box 454, Bishop	Bishop
Rainy Day	K. Moore	Rt. 1, Box 162, Bishop	Bishop
Robbins	S. H. Holder	P.O. Box 134, Bishop	Bishop
Rossi	F. B. Ellis	493 E. Line St., Bishop	
Rossi	G. Stockmen and C. V. Davis	Rt. 1, Box 160, Bishop	
Rossi	Geo. Lasley	Box 454, Bishop	Bishop
St. Charles	Brownstone Mining Co.	P.O. Box 396, Bishop	Darwin
Scheelite 1	G. L. Milovich	Box 505, Bishop	Shannon Canyon
Shamrock	J. C. Esola	P.O. Box 172, Amador City	Bishop
Silver Reef	Zuma Mining Co.		Darwin
Sixty Nine clms.	Dick Beatty	Box 3, Darwin	Darwin
Sonny Boy	R. D. Jones	Rt. 1, Box 162, Bishop	Bishop
Sooner	Sooner Death Valley Mining Co.	Box 898, Trona	
South Side	W. L. Bennett	c/o Furnace Creek Ranch, Death Valley	South Side
Stella & Walter J.	T. C. Greene	P.O. Box 397, Trona	Trona
Tarantula	M. D. Nichols	P.O. Box 397, Trona	Lone Pine
Target	T. H. Stokes	Rt. 1, Box 198, Bishop	Bigpine

Target	J. E. Morhardt	402 Yaney St., Bishop	
Tip Top	J. E. Morhardt	402 Yaney St., Bishop	
Tungsten	Ajax Tungsten Corp.	137 S. Main St., Bishop	Bishop
Tungsten City Dump	C. L. Brown	Box 953, Bishop	Bishop
Tungsten Hill	Duncan & Nettleton	325 Pine St., Bishop	Bishop
Valley View	C. M. Jackson	Box 628, Lone Pine	Bigpine
Yaney	C. G. Scharf	524 N. Main, Bishop	Bishop
White Lime 1	C. E. Lindner		Bigpine
Kern County:			
Aerolite	P. G. McKenry	Box 37, Inyokern	
Agnes B.	T. Herrod		
Bald Eagle 1 and 2	Kenega & Files	Wofford Heights	Bodfish
Billie Burke	C. L. Green	404A Princeton St., China Lake	
Billie Burke	Tregg Mining & Milling Co.	Box 103, Johannesburg	
Blue Grouse	Forminco, Inc.		
Blue Mule	B. H. Silver	Weldon	
Butte Lode, Victory 4	Butte Lode Mining Co.	P.O. Box 195, Randsburg	
Winnie and Mike Mac Cole	Apple Valley Mining & Exploration Corp.	Box 6, Apple Valley	
Ellsie Dillon	Fannie Jane Mining Co.	6520 Wardlow Rd., Long Beach	
Hard Luck	M. Tanous		
Hawk	H. W. Higham	Box 108, Johannesburg	
Hawk and Hawk 1	W. H. Lovett	Randsburg	
Hellot 1	Hellot Mining Co.	3006 Reuter St., Bakersfield	
Hercules	Long & Kivett	Gen. Del., Isabella	Isabella
High Peak	Hatton & Carlson	P.O. Box 297, Inyokern	Inyokern
Hillside	J. Hitchcok	Glenville	Glenville
Hill Top	Ed Kivett	Gen. Del., Isabella	Isabella
Hill Top	Gale Goodwin		Isabella
Hamburg Placer	Ben Stauffer	Box 43, Red Mountain	Randsburg
Jack Ass	Kenega & Files		Breckenridge
Keystone	Keystone Mining & Milling Co.		Havilah
Keystone	O. Stuebner		
King Edward	C. E. Stibbs	Box 281, Johannesburg	Red Mountain
Last Hope	D. Duncan	11046 Cohasset St., Sun Valley	
Lila King	Lila King Mining Co.	Box 168, Randsburg	
Little Rickey	A. Turk	Box 5, Johannesburg	Johannesburg
Little Wonder	G. Rockholt	Gen. Del., Caliente	Caliente
Lucky 2	J. C. Haggard	6400 Franklin Ave., Los Angeles	
Magnolia	P. Siebert	19651 Lanark, Reseda	Inyokern
Major	Trixie Mining Co.		
Marie Rose	J. C. Keifer		
Moonlight 5	Kivett & Horn		Miracle Hot Springs
Morning Star	Forminco, Inc.		

Tungsten—Continued

Mine	Operator	Address	Location
Kern County—Continued			
Nighthawk	Webster & Rosenthal	14906 Lemoli Ave., Gardena	
Owl	National Tungsten Corp.	6758 Hollywood Blvd., Los Angeles 28	
Rainbow	A. Bulla	P.O. Box 65, Red Mountain	
Rimrock	Baker & Moore	P.O. Box 11, Woody	Woody
Scheelite 1 & 2	Long and Kivett	Gen. Del., Isabella	Isabella
Second Chance	McConnehey & Wickliffe	2172 Pico St., San Bernardino	Weldon
Timothy	McGlinchey, Bright & Remp	Box 247, Johannesburg	
Trixie 1	Rockholt and Shirley	Gen. Del., Caliente	Glenville
Valentine Claim	Commercial Fuel Co.	Box G, Randsburg	Randsburg
Victory 4	Williams and Fleming	Box 315, Red Mountain	Red Mountain
Victory 4	Harper & Wilson		Red Mountain
Victory 4	Lila King Mining Co.	Box 168, Randsburg	Red Mountain
Victory 4	Stryker & Harrel		Red Mountain
Victory 4	Cook & Barton		Red Mountain
Weymore	W. Thorpe		
White Rock 1 & 2	Martin Beck	Box 343, Mojave	
Wolf 2	R. R. Vane, Jr.	M.C.A.A.S., Mojave	Weldon
Madera County:			
Bonanza	Gardini, Applegate, Biancula & Lindsay	Roberts Bldg., Madera	Sugar Pine
Coarsegold Dump	Fagon Bros.	El Portal	Coarsegold
Harzett	D. Webster	14906 Lemoli Ave., Gardena	Sugar Pine
Tin Bucket	Gager Bros.	El Portal	Oakhurst
San Joaquin	D. Trainer		North Fork
Strawberry	New Idria Mining & Chemical Co.	1950 Tyler St., Fresno	Bass Lake
Tom Jones	Webster & Rosenthal	14906 Lemoli Ave., Gardena	
Victory Ridge 2	C. S. Tungsten Co.	736 Van Ness St., Fresno	North Fork
Mariposa County:			
Blue Dipper	Incline Mining Co.	1770 22d Ave., San Francisco 22	El Portal
Blue Spat	Incline Mining Co.	1770 22d Ave., San Francisco 22	El Portal
Donna	Donna Mine		
El Portal Mill Tails	El Portal Mill Tails		
Gary Mill	Gary Mining & Mill. Co.	Box 86, El Portal	El Portal
Garnet Queen	Incline Mining Co.	1770 22d Ave., San Francisco 22	El Portal
Happy Jack	C. Warfield		
Lucky Three	Lucky Three Mining Co.	420 14th St., Modesto	Mariposa

Mono County:			
Apex	Ray Swank		Coleville
Black Butte	H. O. Oberg	Star Route, Laws	Dorn Ranch
Black Rock	Wah Chang Mining Corp.	137 Clarke St., Bishop	Benton
Black Rock	D. Beauregard	107 W. Pine St., Bishop	Benton
Nichols	Scharf and Nichols		Crowley Lake
Ruby	H. Woodworth		
Scheelore	Three L. Mining Co.		Bishop
(Jo)	Potter & Wike		
Tungsten Queen	Nevada Consol. Uran., Inc.	1831 Drake Dr., Oakland	Coleville
Tungsten Queen	Nevada Minerals	1831 Drake Dr., Oakland	Coleville
Tungsten Queen	Vandee Tungsten, Inc.		Coleville
West Tower	H. O. Obey	Star Route, Laws	
Nevada County:			
Brunswick	Idaho-Maryland Mines	P.O. Box 1028, Grass Valley	Grass Valley
Placer County:			
Buckeye	Buckeye Mining Co.		Georgetown
Riverside County:			
Milky Way	J. H. Tibbetts		Banning
New World	W. Starke		Banning
Orchid 2	G. Burgoyne	Box 647, Brawley	Desert City
Pigeon Creek	H. T. Lucas Mining Co.	1534 N. Hobart Blvd., Hollywood 27	
Red Ocher 2	C. W. Reno	Box 104, Eagle Mountain	Midland
San Bernardino County:			
Al John	O. H. Wisner	El Mirage Route., Adelanto	
Atolia	Surcease Mining Co.	214 30th St., Sacramento	Red Mountain
Blue Jay 2	D. W. Davis	527 W. Fredricks St., Barstow	Barstow
Bright Outlook	Rainbow Mining & Milling Co.	Valley Wells	
Broker Hills Claim	H. L. Rhone	Box 281, Red Mountain	
Double R	S. E. Rose	Box 2008, Henderson, Nevada	
El Mirage	El Mirage Mining Co.	200 S. Los Angeles St., Anaheim	Adelanto
Fry Mountain	Formineo, Inc.		
Gerrish	V. C. Gerrish	Box 267, Adelanto	Adelanto
Green Top	R. G. Mitchell	Box 282, Randsburg	Red Mountain
Lang	L. Lafferty	1019 Hill St., Santa Monica	
Lang	Lang Mining Co.		
Last Hope Claim	W. N. Means	Box 4, Red Mountain	Red Mountain
Liesera	Liesera Mine		
Lieser-Ray	Okamoto & Harrison	Fenner	
Lost Canyon	J. R. Baker		

Tungsten—Continued

Mine	Operator	Address	Location
San Bernardino County—Continued			
Princess Pat	W. H. Pinchback	11505 Perkins Ave., Whittier	
Rabbit Hole	C. F. Mandt	38363 Rose Marie, Palmdale	Adelanto
Rainbow 1	Rainbow Mining and Milling Co.	Valley Wells	Valley Wells
Starbright	Joe Courson	831 W. Nancy St., Barstow	Barstow
Tanana	Bowald & Twitchell	9642 Vena, Pacoima	Red Mountain
Tungsten Spring	Fred Weick	Box 523, Barstow	Barstow
Tulare County:			
Baker	Conlee & Butcher		Lemon Cove
Baker Bros.	Claud Rouch, Sr. & Jr.	14500 E. Mountain View, Kingsburg	Drum Valley
Beam & Allen	Claud Rouch, Sr. & Jr.	14500 E. Mountain View, Kingsburg	Three Rivers
Big Jim	Tulare County Tungsten Co.	895 Lafayette Ave., Lindsay	Lindsay
Blue Mule	E. Hancel	9921 Robbins Dr., Beverly Hills	
Blue Mule	National Tungsten Corp.	6758 Hollywood Blvd., Los Angeles 28	
Blue Mule	Formineo, Inc.		
Brush Creek 1	S. D. Crotsenburg	Gen. Del., Kernville	Kernville
Buckeye & Midnight	Buckeye Mining Co.	16946 Ventura Blvd., Encino	Three Rivers
Christmas, Yellow Kid	F & O Bower	P. O. Box 7, Inyokern	Inyokern
Consolidated	Claud Rouch, Sr. & Jr.	14500 E. Mountain View, Kingsbury	Orosi
Consolidated Tails	T. Melchert	Star Route, Orosi	Orosi
Credow Mountain	Schrader & Nolan	c/o Morris Ranch, Porterville	Ducor
Deer Creek	Deer Creek Scheelite Mine	1888 E. Date St., Porterville	Hot Springs
Dumball 1	H. W. Cartwright		Mountain Center
Fairview	Flynn Canyon Mining Co.	Box 16, Kernville	Johnsondale
Good Hope	Good Hope Mining Co.	120 O St., Fresno	Three Rivers
Harrell Bros.	Claud Rouch, Sr. & Jr.	14500 E. Mountain View, Kingsbury	
Hilltop	L. G. Embree	Box 583, Kernville	Kernville
Marcus Hunter	Tule River Tungsten & Uranium Properties, Inc.		Porterville
North Fork	North Fork Mining Co.	P.O. Box 257, Woodlake	
Paramount	G. Mehrton	Lemon Cove	Three Rivers
Pioneer	Pioneer Mining Co.	Box 125, Three Rivers	Grouse Creek
Rock House	Rock House Co., Inc.	Box 608, Inyokern	Balis Camp
Rounsville	National Tungsten Corp.	6758 Hollywood Blvd., Los Angeles 28	Porterville
Sherman Peak	Sherman Peak Mining Co.	P.O. Box 583, Kernville	Kernville
Triangle	Joe Ostranger	Box 122, Inyokern	Kernville
Tungsten Tails	Triangle Tungsten Co.	644 W. Duarte Rd., Arcadia	Posey
Tyler	National Tungsten Corp.	6758 Hollywood Blvd., Los Angeles 28	Porterville

Wollastonite *

Operator	Address	Location
Riverside County:		
California Limestone Products Co.	139 S. Beverly Dr., Beverly Hills	Midland
M. L. Jontz Co. (lessee)	Los Angeles	Midland
L. Johnson	P.O. Box 821, Blythe	Midland

* Wollastonite float used as ornamental stone.

Zinc

(Not less than 10,000 lbs. per year)

Mine	Type* of Mine	Operator	Address	Location
Inyo County:				
Christmas Gift, Lucky Jim, Promontory	L	Louis Warnken, Jr.	Lone Pine	Darwin
Darwin	L	The Anaconda Co.	P.O. Box 58, Darwin	Darwin
Defense	L	Foreman & Foreman	P.O. Box 175, Darwin	Modoc
Santa Rosa	L	Norris & Bracken	P.O. Box 111, Keeler	Keeler
Shoshone Group	L	The Anaconda Co.	P.O. Box 58, Darwin	Shoshone
Shasta County:				
Afterthought	Z, U	M. D. Jordan	2852 Fowler Ave., Ogden, Utah	Ingot

*** LEGEND**

L—Lead-zinc mine Z—Copper-zinc mine U—Clean up

DIRECTORY OF SMELTERS AND MINERAL DEALERS REPORTING PURCHASE OF CALIFORNIA METALS PRODUCED IN 1956

Name	Address	Location of plant	Metals reported purchased
American Smelting & Refining Co.	120 Broadway, New York, N. Y.	Amarillo, Tex.	Zinc
American Smelting & Refining Co.	120 Broadway, New York, N. Y.	El Paso, Tex.	Copper, gold, silver
American Smelting & Refining Co.	120 Broadway, New York, N. Y.	Garfield, Utah	Copper, lead, gold, silver
American Smelting & Refining Co.	120 Broadway, New York, N. Y.	Hayden, Ariz.	Copper, gold, silver
American Smelting & Refining Co.	405 Montgomery St., San Francisco	Selby	Copper, lead, gold, silver
American Smelting & Refining Co.	120 Broadway, New York, N. Y.	Tacoma, Wash.	Copper, lead, gold, silver
Anaconda Co.	25 Broadway, New York 4, N. Y.	Anaconda, Mont.	Copper, lead, zinc, gold, silver
Anaconda Co.	25 Broadway, New York 4, N. Y.	Great Falls, Mont.	Zinc
Bethlehem Pacific Coast Steel Corporation	20th and Illinois Sts., San Francisco	San Francisco	Iron ore
Bradley & Ekstrom	24 California St., San Francisco	San Francisco	Manganese, chromite, iron ore
Bradley Mining Co.	660 Market St., San Francisco	Stibnite, Idaho	Antimony
Braun Corporation	1363 S. Bonnie Beach Place, Los Angeles	Los Angeles	Quicksilver
Coast Chemical Division, F. W. Berk & Co., Inc.	Sharon Bldg., San Francisco	San Francisco	Quicksilver
Columbia-Geneva Steel Division, U. S. Steel Co.	P.O. Box 269, Salt Lake City, Utah	Geneva, Utah	Manganese and iron ores
International Smelting & Refining Co.	Kearns Bldg., Salt Lake City, Utah	Miami, Ariz.	Copper, gold, silver
International Smelting & Refining Co.	Kearns Bldg., Salt Lake City, Utah	Tooele, Utah	Copper, lead, zinc, gold, silver
Kaiser Co., Inc.	P.O. Box 217, Fontana	Fontana	Iron ore, manganese ore, chromite
Kennecott Copper Corp.	120 Broadway, New York, N. Y.	McGill, Nev.	Copper, gold, silver
Lippincott Lead mines	Box 1811, Santa Ana	Santa Ana	Lead and zinc ore
Mefford Chemical Co.	5353 Jillson Ave., Los Angeles	Los Angeles	Quicksilver
Pacific Vegetable Oil Co., Bernard T. Rocca	62 Townsend St., San Francisco	San Francisco	Quicksilver
Phelps-Dodge Corp.	40 Wall St., New York, N. Y.	Ajo, Ariz.	Copper, gold, silver
Quicksilver Producers Ass'n., Irving Ballard, Sec'y.	407 Sansome St., San Francisco	San Francisco	Quicksilver
Sullivan Mining Co.	Wallace, Idaho	Silver King, Idaho	Zinc
Twining Laboratories	2527 Fresno St., Fresno	Fresno	Tungsten ore
U. S. Mint	Duboce & Market Sts., San Francisco	San Francisco	Gold, silver
U. S. Smelting, Refining & Mining Co.	Newhouse Bldg., Salt Lake City, Utah	Midvale, Utah	Copper, lead, zinc, gold, silver
Union Carbide Nuclear Co.	30 E. 42d St., New York, N. Y.	Bishop	Tungsten ore
Western Gold & Platinum Works	525 Harbor Blvd., Belmont	Belmont	Platinum, gold, silver*
Wildberg Bros. Smelting & Refining Co.	742 Market St., San Francisco	San Francisco	Platinum, gold, silver*

* Gold and silver in special high-grade ores only.

DIRECTORY OF MINERAL DEALERS AND COMMERCIAL LABORATORIES

List of Mineral Dealers, Custom Mills, and Commercial Grinding Plants in California

Firm	Remarks
American Mineral Co., 840 S. Mission Rd., Los Angeles	Commercial grinding of minerals.
Atkins, Kroll & Co., 417 Montgomery St., San Francisco	Dealer in tungsten ores, mercury, gypsum and limerock.
Baroid Sales Division, National Lead Co., 19301 South Santa Fe Court, Los Angeles	Talc and other soft non-metallic minerals ground by contract or purchased.
Bishop Concentrate & Cleaning Co., Bishop	Custom mill; purchases tungsten ores and base metal ores.
Blood, Harry E., Co., 5028 Alhambra Ave., Los Angeles	Dealer in industrial sand and silica products.
Bradley & Ekstrom, 24 California St., San Francisco 11	Dealer in all commercial minerals.
Brumley-Donaldson Co., 75 Market St., Oakland, and 3050 E. Slauson Ave., Huntington Park	Dealer in sand, clay, limestone, dolomite, and other minerals.
Burton Bros., Rosamond, Kern County	Custom cyanide mill. Gold and silver ores purchased.
Castle Crags Chrome Co., Box 126X, Castella	Dealer in or custom milling of chrome ores.
Commercial Minerals Co., 310 Irwin St., San Francisco 7	Commercial grinding by contract or minerals purchased.
Hidecker Brick Co., Inc., 4054 N. Mission Rd., Los Angeles	Clay grinding plant; non-metallic minerals ground by contract or purchased.
Hill Bros. Chemical Co., 2159 Bay St., Los Angeles	Grinding asbestos, and custom milling of small lots of soft non-metallic minerals.
Huntley Industrial Minerals, P.O. Box 305, Bishop	Dealer in talc, pyrophyllite, garnet sands, clay and mica.
Industrial Minerals & Chemical Co., 836 Gilman St., Berkeley	Non-metallic minerals ground by contract or purchased.
Kennedy Minerals Co., 2556 E. Olympic Blvd., Los Angeles	Non-metallic minerals ground by contract or purchased.
Los Angeles Chemical Co., 4545 Ardine Ave., South Gate	Dealer in non-metallic minerals.
Metals Disintegrating Co., Inc., 1069 Second St., Berkeley 10	Non-metallic mineral grinding by contract or purchase.
Sierra Talc & Clay Co., 1608 Huntington Drive, South Pasadena	Dealer in talc and clays.
Southern California Minerals Co., 320 S. Mission Rd., Los Angeles	Dealer in talc, clay and other minerals.
Twining Laboratories, 2527 Fresno St., Fresno	Purchase and concentrate tungsten ores on a custom basis, also commercial grinding.
Union Carbide Nuclear Co., Bishop	Tungsten mill, ore purchased.
Western Talc Co., 1901 E. Slauson Ave., Los Angeles	Non-metallic mineral grinding plant; minerals ground by contract or purchased.

LIST OF COMMERCIAL ASSAY AND TESTING LABORATORIES

Firm	Services
San Francisco Area	
American Spectrographic Laboratories, 557 Minna St., San Francisco	Spectographic analysis of minerals and water by quantitative methods. Radioactivity measurements.
Ball, C. M., 911 University Ave., Berkeley 10	Fire assay, chemical analysis of ores and minerals.
Curtis & Tompkins, Ltd., 236 Front St., San Francisco 11	Chemical analysis and specification testing of metallic ores, metals, and non-metallic minerals.
Hall Laboratories, Inc., 1485 Bayshore Blvd., San Francisco	Consulting water chemists.
Hanks, Abbot A., Inc., 624 Sacramento St., San Francisco	Fire assay, chemical analysis of metals, alloys, cement, ores and minerals; physical tests of structural materials; spectographic analysis.
Hersey Inspection Bureau, 3405 Piedmont Ave., Oakland	Engineers, chemists, and testers of building materials, foundations.
Metallurgical Laboratories, 604 Mission St., San Francisco 5	Chemical analysis of ceramic materials, chemical analysis of ores and minerals, chemical analysis of iron, steel, brass, babbitts, aluminum, magnesium, and alloys; spectrographic analysis.
Pacific Chemical Laboratories, 350 Clay St., San Francisco	Chemical analysis of ceramic materials, chemical analysis of minerals, spectrographic analysis, water analysis.
Pittsburg Testing Laboratory, 651 Howard St., San Francisco 5	Fire assay, chemical analysis of ceramic materials, chemical analysis of ores and minerals, X-ray-metallurgical examinations, physical tests, spectrographic analysis, water analysis.
Siefert, H. G. Laboratory, 3403 Piedmont Ave., Oakland 11	Chemical analysis of ores and minerals, physical and chemical test of petroleum products, and chemical ceramic testing.
Western Gold and Platinum Works, 525 Harbor Blvd., Belmont	Fire assay, chemical analysis of ores and minerals, ore dressing, beneficiation.
Western Machinery Co., 650 Fifth St., San Francisco	Ore dressing, mineral beneficiation, coal washing, sand preparation. Flowsheet determination, plant design and construction.
Los Angeles Area	
California Testing Laboratories, Inc., 619 E. Washington, Los Angeles 15	Chemical analysis of ores, minerals, ceramic materials. Physical, electronic and environmental testing.
Dorr-Oliver, Inc., 811 W. Seventh St., Los Angeles 17	Ore dressing, mineral beneficiation.
Eisenhauer Laboratories, 322 S. San Pedro St., Los Angeles 13	Fire assay, chemical analysis of ores and minerals, ore testing.
Herr Laboratory, 5176 Hollywood Blvd., Los Angeles 27	Fire assay, chemical analysis of ores and minerals, spectrographic analysis, and rare metals chemistry.
Hollywood Testing Laboratories, 7416 Santa Monica Blvd., Hollywood	Fire assay, chemical analysis of ceramic materials, chemical analysis or ores and minerals, ore dressing, beneficiation, petrographic analysis, physical tests, spectrographic analysis, water analysis, X-ray diffraction.
Hunt, Robert W., Co., 6353 Miles Ave., Huntington Park	Chemical analysis of ores and minerals.

LIST OF COMMERCIAL ASSAY AND TESTING LABORATORIES—Continued

Firm	Services
Los Angeles Area—Continued	
Keldon Research Corp., 2565 Belgrave Ave., Huntington Park	Chemical analysis of ores and minerals, chemical analysis of ceramics; spectrographic analysis, water analysis, mineral evaluation.
Kennard & Drake, 3364 E. 14th St., Los Angeles 23	Chemical analysis of ceramic materials, chemical analysis of ores and minerals, ore dressing, beneficiation, physical tests, spectrographic analysis.
Los Angeles Testing Laboratory, 1300 S. Los Angeles St., Los Angeles 15	Fire assay, chemical analysis, ceramic analysis of ores and minerals, ore dressing, beneficiation, physical tests, spectrographic analysis, cargo inspection.
Meco Assayers, 417 S. Hill St., Los Angeles 13	Fire assay, chemical analysis of ores and minerals.
Metal Control Laboratories, 2735 E. Slauson Ave., Huntington Park	Chemical analysis of ores, minerals and metals, physical tests, spectrographic analysis, metallurgical examinations, and quantometric analysis.
Minerals Engineering Co., 417 S. Hill St., Los Angeles 13	Ore dressing, beneficiation of ores and minerals, assaying, quantitative spectrographic analysis.
National Supply Co., The, 1524 Border Ave., Torrance	Chemical analysis of ores and minerals, ore dressing, beneficiation, physical tests.
Osborne, Raymond G., Laboratories, 235 W. 27th St., Los Angeles 7	Chemical analysis of ores and minerals, physical testing of construction materials.
Quality Control Laboratory, 2606 N. Durfee Ave., El Monte	Fire assay, chemical analysis of ores, minerals, and water, spectrographic analysis and physical test.
Sill, Harley A., 1011 S. Figueroa St., Los Angeles 15	Fire assay, chemical analysis of ores and minerals, pilot plant testing, ore treatment research.
Smith-Emery Co., 781 E. Washington Blvd., Los Angeles 21	Fire assay, chemical analysis of ceramic materials, chemical analysis of ore and minerals, petrographic analysis, spectrographic analysis.
Southwestern Engineering Co., 4800 S. Santa Fe Ave., Los Angeles 58	Ore dressing, beneficiation of minerals.
Triplett & Barton, Inc., 831 N. Lake St., Burbank	Chemical analysis of ores and minerals, spectrographic analysis (rare earth analyses), X-ray diffraction metallography.
Truesdail Laboratories, Inc., 4101 N. Figueroa, Los Angeles 65	Chemical analysis of ores and minerals, physical testing of ferrous and nonferrous metals and alloys.
von Huene, Rudolph, 865 N. Mentor Ave., Pasadena 6	Thin and polished sections prepared.
Other Areas	
Bishop Assay Office, 126 S. Warren St., Bishop	Fire assay; chemical analysis of ores, minerals, and tungsten ores; testing laboratory.
Clarkson Laboratory and Supply, Inc., 1144 30th St., San Diego	Fire assay, chemical and spectrographic analysis of ores and minerals.
Coast Laboratories, 1859 S. Van Ness Ave., Fresno 15	Fire assays, and chemical analysis of ores and minerals.
Gardiner, Phillip M. & Assoc., P.O. Box 123, Bishop	Fire assay, ores and minerals, control and umpiring of tungsten ores and concentrates.

LIST OF COMMERCIAL ASSAY AND TESTING LABORATORIES—Continued

Firm	Services
Other Areas—Continued	
Hornkohl Laboratories, 714 Truxton Ave., Bakersfield	Mineral and ore process research, chemical and spectrographic assays of ores; umpire assayers; corrosion and water treatment; testing of petroleum products, muds, oil cores, aggregates, concrete and steel. Concrete coring.
Howard, K. B. Co., P.O. Box 1207, Lindsay	Chemical analysis of ores, minerals, and water, chemical and physical test of petroleum.
Morse Laboratories, 316 16th St., Sacramento	Fire assay, chemical analysis of ceramic materials, chemical analysis of ores and minerals, ore dressing, beneficiation, physical tests, spectrographic analysis, chemical and mining engineers.
Peninsula Laboratories, 544 S. San Antonio Rd., Mountain View	Chemical analysis of ores, minerals, and metals; ore and mineral beneficiation, chemical and metallurgical research.
Rombough, M. R. Laboratories, 3069 Del Paso Blvd., North Sacramento 15	Fire assay, quantitative analysis of ores and minerals, testing laboratories and ore beneficiation.
San Joaquin Research Laboratories, Box 1987, 2253 S. El Dorado St., Stockton	Fire assay, chemical analysis of ores and minerals.
Twining Laboratories, 2527 Fresno St., Fresno	Fire assay, chemical analysis of ceramic materials, chemical analysis of ores and minerals, ore dressing, petrographic analysis, physical tests, spectrographic analysis, water analysis, X-ray diffraction.
Valley Analytical & Testing Laboratories, Inc., 356 E. Main St., El Centro	Chemical analysis of ores, minerals and water. Engineering materials tests.

METAL AND MINERAL REVIEW FOR 1956 *

By Charles W. Merrill **

Both the metals and nonmetals industries gained about 10 percent in output in 1956. Nonmetals continued the steady upward trend followed since 1944 and reached a record high of $3.3 billion. Value of metals produced increased for the third consecutive year and exceeded $2.2 billion.

A month-long midsummer steel strike and enactment of a National Highway Program were major events influencing the mineral industries. Prices were usually steady; but copper was an exception, reaching a 90-year high of 46 cents in February, holding this level until July, and then declining sharply to 36 cents by the end of the year. Lead and zinc prices were stabilized by stockpile purchases and by siphoning off new foreign supply through barter of agricultural surpluses.

Uranium-ore reserve and production information released by the Atomic Energy Commission disclosed that the domestic exploration program had been extremely successful. The uranium mining and processing industry continued to grow.

Production capacity continued to expand for many minerals. Although the outlook at the end of the year was largely favorable, it appeared that most mineral-supply deficiencies of 1954-55 had been overcome and that market conditions for producers were less promising than earlier in the year.

ALUMINUM

By R. A. Heindl, Assistant Chief
Branch of Light Metals

Although in 1956 primary aluminum production attained a record 1,680,000 tons (an increase of 7 percent or 114,000 tons over the previous year), of possibly greater significance was reversal of the supply-demand picture during the year. Aluminum was in short supply from the Korean War to mid-1956, but by the end of 1956 it had moved into a surplus position. Two producers of primary aluminum took preliminary steps toward selling metal to the Government under aluminum-expansion-goal contracts. Stock increases at the producing plants were another indication of ample supplies. At the end of May these stocks totaled 12,000 tons—by the end of the year they had increased more than 8 times to 102,000 tons.

Despite the apparent surplus of aluminum, the 3 major producers and 2 prospective producers, Olin Revere Metals Corp. and Harvey Aluminum Co., had large new production facilities under construction. These facilities were expected to increase the capacity for producing primary aluminum—1.75 million tons at the end of 1956—to 2.5 million tons by the end of 1958. Three of the new plants will be in the Indiana-Ohio-West Virginia area. Location of plants in this area reflects a significant departure from the pattern previously established by the industry, in that these plants will use bituminous coal instead of hydroelectric power as a source of energy. Economic studies by the industry had indicated that the lower transportation cost resulting from being close to the southern alumina-producing area and near the eastern consuming markets would offset higher power costs.

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* Reprinted from *The State Geologists' Journal,* October 1957.
** Chief, Division of Minerals, Bureau of Mines, U. S. Department of the Interior.

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ANTIMONY

By Abbott Renick, Commodity Specialist
Branch of Base Metals

World antimony supply and demand were almost in balance in 1956, with ample supplies to meet requirements of industry and stockpiling.

The United States continued to depend upon foreign sources for antimony. In 1956, new supply of primary antimony totaled 14,600 short tons, a 7 percent decrease from 1955. Of the total quantity available, domestic mine production supplied 4 percent, antimony recovered from domestic and foreign silver lead ores 14 percent, and imports 82 percent.

Consumption of primary antimony totaled 13,000 tons, virtually unchanged from 1955. The domestic price of antimony metal remained at 33 cents a pound, f.o.b. Laredo, Tex. World production of antimony totaled about 54,000 short tons.

ARSENIC

By Abbott Renick, Commodity Specialist
Branch of Base Metals

The arsenic industry prospered in 1956. Total shipments of white arsenic—19,000 short tons—were the highest since 1945. As a result of heavy boll weevil infestations in the cotton-growing areas of the South, apparent consumption rose to 25,000 tons, compared with 19,000 tons in 1955. The increased demand for arsenic in the preparation of insecticides reduced year-end stocks of white arsenic to the lowest since 1951.

Total imports of white arsenic during 1956 were 6,400 tons, a decline of 11 percent from 1955. White arsenic continued to be quoted at 5½ cents a pound.

ASBESTOS

By D. O. Kennedy, Assistant Chief
Branch of Construction and Chemical Materials

Over 90 percent of the chrysotile asbestos consumed in the United States during 1956 was imported from Canada, including the low-iron chrysotile of strategic interest. The domestic purchase program of Arizona asbestos assisted in maintaining the production of long fibers, but production of short fibers decreased 33 percent in 1956. Domestic mines in Vermont, Arizona, and California supplied only 6 percent of the 727,000 tons of asbestos consumed by American industries in 1956.

Amosite and crocidolite have particular physical properties that make them more desirable for some asbestos products than chrysotile, but no deposits of these varieties are known within the United States. For several years approximately 11,000 tons of amosite has been imported from Africa. Imports of crocidolite increased to nearly 20,000 tons in 1956.

BARITE

By A. E. Schreck, Commodity Specialist
Branch of Construction and Chemical Materials

Record highs in barite production and consumption were established in 1956. Oil-well drilling used over 90 percent of the ground barite. Imports exceeded the record high set in 1955.

More than 1.3 million tons of primary barite was produced in the United States in 1956. Arkansas remained the leading producing state, with Missouri second, Nevada third, and Georgia fourth. Production

of barite was also reported in California, Idaho, Montana, New Mexico, South Carolina, and Tennessee.

A new 175- to 200-ton-per-day grinding plant began operation in Nevada, and a new barium-chemical plant in Kansas began producing.

Because of growing demand, the search for new barite resources in the United States and other countries continued.

Outlook for the barite industry appears bright. With the growing demand due to increased well drilling, expansion of production and processing facilities, and development of new deposits were anticipated.

BAUXITE

By R. C. Wilmot, Commodity Specialist
Branch of Light Metals

The 1.7 million short tons of bauxite produced in the United States in 1956 represented little change from the previous year. Arkansas produced about 96 percent of the total; the remainder came from Alabama and Georgia. Imports of more than 6 million tons composed 77 percent of the total supply.

The suspension of duty on crude and calcined bauxite was extended until July 16, 1958, and for the first time the duty on alumina was suspended for 2 years ending July 17, 1958.

To supply alumina for the expanding aluminum industry, construction was begun on 1.7 million tons of new alumina-plant capacity. The Aluminum Co. of America was building a plant with an annual capacity of 750,000 tons of alumina at Point Comfort, Tex. The Reynolds Metals Co. was expanding its La Quinta, Tex., plant 183,000 tons to a capacity of 548,000 tons. Olin Revere Metals Corp. was building a 350,000-ton-capacity plant at Burnside, La., and Kaiser Aluminum & Chemical Corp. started work on a plant at Gramercy, La., that will have a rated annual capacity of 430,000 tons. Upon completion of these plants, the annual domestic alumina-production capacity will be about 5.2 million tons, and bauxite requirements will be over 10 million tons a year.

The Harvey Aluminum Co. signed contracts with two Japanese firms to supply alumina for its reduction plant being built at The Dalles, Oreg. This will be the first time that a significant quantity of foreign alumina will be used at an American aluminum-reduction plant.

Anaconda Co. planned a $1 million pilot plant at Anaconda, Mont., to test its process for extracting alumina from clay.

During the year a major bauxite deposit was discovered on the Cape York Peninsula, Australia. Reports indicated that the reserves may contain many hundred millions of tons of ore analyzing 56 to 58 percent alumina. Exploration continued in Hawaii on recently discovered deposits. Preliminary reports indicate 600 million tons of low-grade material.

BERYLLIUM

By Donald E. Eilertsen, Commodity Specialist
Branch of Rare and Precious Metals

In 1956 the domestic production of beryl totaled 460 short tons, about 39 percent less than the record output in 1953; consumption, approximately 4,500 tons, was highest in history. Beryl imports totaled 12,371 tons. The average price of domestic beryl was $514 per ton and for imported beryl $360 per ton.

New plant construction to produce reactor-grade beryllium for the Atomic Energy Commission was started by the Beryllium Corp. at Hazelton, Pa., and by the Brush Beryllium Co. at Elmore, Ohio. Each firm is to produce 50 tons of the metal annually over a period of 5 years for the AEC, and production is to begin in 1957.

Bureau of Mines research on methods of concentrating low-grade beryl from pegmatites progressed satisfactorily. From South Dakota ores low-grade beryl concentrate could be obtained by the sulfonate flotation process; and, upon re-treatment with other reagents, a commercial-grade concentrate could be produced. Additional work was needed to improve and simplify procedures and reduce losses of beryl. Hydrometallurgical studies on extracting beryllium from low-grade beryl concentrate were also continued. Beneficiation studies that appeared to be promising, were also made on beryl-spodumene pegmatites and mill tailing from Kings Mountain, N. C.

BISMUTH

By Abbott Renick, Commodity Specialist
Branch of Base Metals

World production of bismuth set a new record in 1956 at approximately 5.4 million pounds, compared with 4 million pounds in 1955.

Domestic consumption of refined bismuth totaled 1.5 million pounds, virtually unchanged from the previous year. Consumption of bismuth in the manufacture of pharmaceuticals totaled 425,000 pounds—a decrease of 46,000 pounds or 10 percent below the previous year. Consumption of bismuth metal was 72 percent of the total, approximately the same as in 1955.

Imports of refined metal totaled 900,000 pounds and represented a 54-percent increase from the previous year.

The quoted market price of bismuth metal in New York remained throughout the year at $2.25 a pound in ton lots, unchanged since September 1950.

BORON

By Henry E. Stipp, Commodity Specialist
Branch of Construction and Chemical Materials

New applications for boron and boron compounds, including an antiknock additive for gasoline, a neutron absorber in the atomic-energy field, an abrasive material approaching the hardness of diamond, and proposed uses as fuel for jet planes and rockets received considerable publicity in 1956. Conversion to open-pit mining by the U. S. Borax & Chemical Corp. near Boron, Calif., and construction of new concentrating and refining plants at the mine highlighted the industrial expansion. Preliminary figures indicate that approximately 945,000 short tons (gross weight) of boron minerals with a B_2O_3 content of about 315,000 short tons and value of $39,592,000 was sold or used by producers during 1956. Prospects for a substantial increase in the future demand for boron minerals appear to be favorable due to development of new uses for boron products.

CADMIUM

By Arnold M. Lansche, Commodity Specialist
Branch of Base Metals

Cadmium-metal production attained a new peak in 1956, output totaling 10.4 million pounds—6 percent above that of 1955. Total supply, consisting of metal output at domestic plants plus imports for con-

sumption, exceeded demand by 8 percent. Imports for consumption were about 3.1 million pounds for the year, more than double the 1955 total. Italy was the largest supplier of metallic cadmium, shipping 937 thousand pounds to the United States. Mexico was the only supplier of flue dust. Cadmium-metal stocks declined 7 percent during the year, and shipments by producers were off 5 percent. Apparent consumption was 12.5 million pounds, 17 percent above that of last year. Exports declined 8 percent.

Quoted price for cadmium sticks, bars, and special platers' shapes was $1.70 a pound all year.

A new line of pigments, the cadmium-mercury lithopones, was introduced to the market in 1956 and has proved competitive to the cadmium sulfoselenide pigments. Another use may develop through industrial research that has shown that cadmium compounds reduce surface tackiness and degradation mechanisms in vinyl and other resins.

CEMENT

By D. O. Kennedy, Assistant Chief
Branch of Construction and Chemical Materials

Growth of the portland-cement industry continued during 1956, as production and consumption increased to new highs of 316 and 309 million barrels, respectively.

Expansion of plant capacity to 349 million barrels (an increase of 11 percent in 1956) eased the pressure on cement plants in most areas. During 1956 plants utilized only 90 percent of their productive capacity as compared with 94 percent in 1955. Although plant expansions did not reach the expected 357 million barrels for the continental United States, consultation with various cement companies indicated that nearly 37 million barrels would be added in 1957 to meet the figures forecast in 1955 by these companies.

Strikes in the domestic cement industry caused shortages of cement to develop in many areas, in spite of the enormous increases in plant capacities.

CHROMIUM

By Wilmer McInnis, Commodity Specialist
Branch of Ferrous Metals and Ferroalloys

Domestic chromite furnished only 7 percent of total United States supply. Production (shipments) was reported at 161,952 short tons; consumption was 1,846,600 tons, averaging 43.5 percent Cr_2O_3.

Nearly all domestic output was purchased by the Government; about 75 percent was submetallurgical-grade concentrate (averaging 38.5 percent Cr_2O_3 with a Cr:Fe ratio of 1.7:1) mined at the Mouat mine in Stillwater County, Mont. Most concentrate from other producing states —California, Oregon, Washington, and Alaska—was of specification grade.

The Kenai Chrome Co. completed constructing a $70,000 mill for concentrating lower grade ores at its Star 4 property on Red Mountain near Seldovia, Alaska.

A 300-ton mill and other facilities were reportedly purchased for installation at the Chrome Queen mine in Yreka, Calif.

United States consumption of chromite ore and concentrate reached a new high in 1956. The metallurgical industry consumed about 66 percent of the total; the refractory industry consumed about 26 percent and the chemical industry about 8 percent. Concentrate consumed by

the metallurgical industry averaged 46.8 percent Cr_2O_3. Average grade consumed by the refractory industry was 34.4 percent Cr_2O_3, and chemical grade averaged 45.4 percent.

United States chromite imports were 19 percent higher than in 1955. Of the nearly 2.2 million tons imported, 31 percent was from the Philippines, 24 percent from Turkey, 21 percent from Union of South Africa, and 16 percent from the Federation of Rhodesia and Nyasaland. The remaining 8 percent was from 10 other countries. Most of the refractory-grade ore came from the Philippines and all of the chemical-grade from Union of South Africa.

COBALT

By Hubert W. Davis, Commodity Specialist
Branch of Ferrous Metals and Ferroalloys

The uptrend in world production of cobalt continued for the seventh successive year to establish a new record of 16,000 short tons in 1956, despite smaller demand by the United States, by far the largest market for cobalt. In consequence of expansion programs underway chiefly in Belgian Congo and Canada and new production from Cuba and Northern Rhodesia, a substantial increase in output is anticipated within a few years. Accordingly, the disparity between production and demand is expected to become greater, unless uses increase greatly. In anticipation of increased supply, a cobalt information bureau, supported by an international association of cobalt producers, was established at Battelle Memorial Institute, Columbus, Ohio, in mid-1956. Its purpose was to encourage cobalt research and development, to give widespread distribution of technical information, and to provide technical aid to users.

The Union Minière du Haut-Katanga, Belgian Congo, has an expansion program underway that includes the opening of new mines rich in copper and cobalt and the construction of copper and cobalt electrolytic plants at Luilu for refining the ores. The annual capacity of the cobalt refinery will be about 4,000 short tons. The new flotation concentrator of Chibuluma Mines, Ltd., near Ndola, Northern Rhodesia, began producing cobalt concentrate May 6. The concentrate will be converted into a 10-percent matte, which will probably be refined in Europe. Freeport Sulphur Co. announced it would build a refinery at Braithwaite, La., with a capacity to produce 50 million pounds of nickel and 4.4 million pounds of cobalt annually from laterite ore from Moa Bay, Cuba.

The United States continued to depend on foreign sources for much the greater part of its cobalt requirements. However, domestic mine production (2,539,000 pounds in 1956) was equivalent to 27 percent of the cobalt consumed in the United States, compared with 19 percent in 1955. Bethlehem Cornwall Corp. in Pennsylvania, Calera Mining Co. in Idaho, and National Lead Co. in Missouri continued to produce cobalt concentrates from domestic ores. Consumption and imports of cobalt in 1956 were 9,562,000 and 15,577,000 pounds, respectively.

The price of cobalt metal was reduced 25 cents a pound to $2.35, effective December 1. This was the first cut in price of cobalt metal since February 1934.

COLUMBIUM TANTALUM

By William R. Barton, Commodity Specialist
Branch of Rare and Precious Metals

Domestic production and consumption of columbium-tantalum attained new records in 1956. Due to halting of United States Government

purchases, world production decreased from its 1955 record total. Domestic production was more than 216,000 pounds in 1956, compared with 12,900 pounds in 1955. World production was 9,640,000 pounds in 1956, compared with 11,560,000 pounds in 1955. Domestic consumption increased over one-third.

The sharp rise in domestic production was due to Porter Bros. Corp. placer euxenite mine at Bear Valley, Idaho. The mine, in its first full year of production, accounted for more than 99 percent of United States mine shipments in 1956. Maine reported the second largest shipments during the year.

The outlook for the two metals continued encouraging as the Atomic Energy Commission requested bids for delivering 15,000 pounds of columbium in October. The orders for tantalum-containing capacitors were reported to be 48 weeks ahead of delivery, and demand was expected to increase. New industrial facilities were under construction to alleviate the situation by greatly expanding industrial capacity for production of both metals.

A pilot plant began processing pyrochlore-type ore at Beaucage Mines, Ontario. If the process proves economically successful, it will help to reduce United States dependence on overseas supplies.

COPPER

By A. D. McMahon, Commodity Specialist
Branch of Base Metals

Domestic mine, smelter, and refinery production of copper reached new highs in 1956, and consumption slightly exceeded that for the previous year. Output of recoverable copper from domestic mines established a new annual record of 1,100,300 tons, or 10 percent above that of 1955. This peak was attained by the combination of new and expanded mine production, the incentive of high prices, and uninterrupted operations. Contributing to the last factor were the agreements negotiated in June between principal producers and the International Union of Mine, Mill, and Smelter Workers.

The inadequate supply position of copper that prevailed during the latter part of 1955 carried forward and became increasingly severe through the first quarter of 1956, with demand rising to its highest level in March. Domestic and foreign copper quotations advanced to alltime peaks, with the foreign price substantially above the domestic level. As a result of this disparity, much refined copper of foreign origin was diverted abroad.

The long-awaited transition to an easier supply situation appeared at the beginning of the second quarter, when there were signs that supply at existing prices exceeded demand. Although consumption remained high through May, additional copper coming into the market from new properties and expanded operations and the disappearance of high-price sales led to the first price reduction by the London Metal Exchange late in March. June and July layoffs and vacations at fabricating plants, buying resistance and foreign competition added to the pressure. On July 10 the price dropped from 46 cents to 40 cents, the first reduction in the United States price of copper in more than 2 years. A progressive drop in monthly consumption during the latter half of 1956, with a high rate of mine production, indicated develop-

ment of an oversupply of copper, and the price fell to 36 cents in October, the year closing at this level.

Several actions were taken in efforts to stabilize or take advantage of the changed supply-demand position. In March the Office of Defense Mobilization had postponed stockpile deliveries from June 30 to December 31, 1956, to alleviate the then copper shortage, but in May authorized General Services Administration to negotiate with contractors for orderly delivery of about 40,000 tons of copper through the fourth quarter of 1957 to take advantage of the reverse condition; and the Bureau of Foreign Commerce relaxed copper-export restrictions for the third and fourth quarters of the year. In October two major producers, The Anaconda Co. and Phelps Dodge Corp., announced cutbacks of 16 and 7½ percent, respectively, at their Montana and Arizona properties.

Despite the present excess supply of copper with relation to current demands, the copper-producing industries throughout the world are apparently confident in the future, as evidenced by planned expansion that is estimated to further increase world production about 900,000 tons by 1965. Large exploration, development, and expansion projects are scheduled for copper-producing areas of the United States, Canada, the Philippines, South America, and Africa, from which preliminary reports are encouraging.

DIAMOND (INDUSTRIAL) AND SUBSTITUTES

By Henry P. Chandler, Commodity Specialist
Branch of Ceramic and Fertilizer Materials

World production of industrial diamond again increased, from 17 million carats in 1955 to 18.3 million carats in 1956. Imports into the United States in 1956 were 15.9 million carats valued at $73.1 million, compared with 15.1 million carats valued at $66.3 million in 1955.

FLUORSPAR

By Robert B. McDougal, Commodity Specialist
Branch of Construction and Chemical Materials

Domestic fluorspar production increased substantially in 1956; imports and consumption reached alltime highs.

The Tariff Commission investigated the effect of imports of Acid-grade fluorspar upon the domestic producers. Three commissioners found that imports posed a serious threat to domestic producers and recommended withdrawal of the tariff concession granted earlier in a trade agreement, but the other three commissioners took the opposite position. On March 18, 1956, the President accepted the conclusions of the commissioners who held that there was neither present nor threatened injury to the domestic producers; consequently, no changes were made in the tariff regulations. Public Law 733, passed in July to assist domestic fluorspar producers, provided a 250,000-ton market for newly mined Acid-grade fluorspar at $53 per short dry ton. In July the Office of Defense Mobilization announced a premium price purchase program for Metallurgical-grade fluorspar for the strategic stockpile. The General Services Administration was to buy 72½ effective fluorspar at $39.50 in Illinois and Kentucky and $33.50 per ton in the Western States. Later the western price was raised to $39.50 per ton. Pennsylvania Salt Manufacturing Co. began production in May at its Dyer Hill mine. This ore was concentrated at Pennsalt's mill at Mexico, Ky. Develop-

ment of a fluorspar deposit near Fish Creek in Mineral County, Mont., was reported.

United States production of finished fluorspar totaled 330,000 tons in 1956. Illinois was again the largest fluorspar-producing State, shipping approximately 54 percent of the total. Montana ranked second with about 18 percent of the total. Output in Kentucky, Nevada, and Utah increased, whereas in Colorado it declined.

Major producers were active throughout the year. Crude fluorspar mine production totaled 922,000 short tons in 1956 compared with 656,000 tons in the previous year. Fifteen mills treated 756,000 tons of material to recover 254,000 tons of fluorspar.

Prices continued to rise during 1956. Trade-journal quotations indicated that Metallurgical-grade fluorspar prices were about $8 per ton higher at the end of the year than the beginning. Some ceramic prices increased, others remained steady, and Acid-grade fluorspar closed out $5-7.50 higher than at the start.

Consumption was the highest in history—621,000 short tons, of which 289,000 tons was consumed in the production of hydrofluoric acid. Ceramic industries consumed 36,303 tons; metallurgical industries used 264,434 tons in steel production and 13,738 tons at iron foundries. Other industries used 17,356 tons of fluorspar.

The industry anticipates a growing demand for fluorspar based on developments in the aluminum and steel industries, and in such new uses as high-energy fuels.

GOLD

By J. P. Ryan, Commodity Specialist
Branch of Rare and Precious Metals

Although domestic production declined slightly, world production of gold in 1956 increased significantly owing almost entirely to expansion of output in Union of South Africa.

Domestic gold output declined 4 percent in 1956 to 1,814,000 ounces. About 76 percent of this output came from four States—South Dakota, Utah, Alaska, and California. Of the total domestic yield, 60 percent was recovered from gold ores and placers; the remaining 40 percent was recovered mostly as a byproduct of the smelting of base-metal ores and concentrates.

World production of gold in 1956 was estimated at 37.6 million ounces, of which nearly 42 percent came from Union of South Africa. On the basis of estimated production, the Soviet Union continued to rank second, followed by Canada and the United States.

During 1956 the range of quotations on the international free gold market for bar gold was narrow, remaining close to the fixed United States Treasury price of $35 per ounce, although the volume of trading was the highest since 1949. Demand for hoarding was estimated by a leading bullion firm at over 10 million ounces. Other significant features were the heavy sales by the Soviet Union, estimated at 4.3 million ounces, and establishment of free gold markets in Belgium and Canada.

Rising costs of operation in conjunction with a fixed price of gold, continued to affect adversely the gold-mining industry. In several countries, gold producers became increasingly dependent on government assistance in the form of subsidies or tax concessions.

GRAPHITE

By Donald R. Irving, Assistant Chief
Branch of Ceramic and Fertilizer Materials

In 1956 the world supply of all types and grades of natural graphite exceeded demand, as a result of somewhat lower consumption than in 1955. Southwestern Graphite Co., Burnet, Tex. (high-grade flake graphite), and Graphite Mines, Inc., Cranston, R. I. (low-grade amorphous graphite), continued to be the only domestic producers, although all amorphous graphite in Mexico was produced by subsidiaries of United States companies.

Domestic consumption decreased from 45,000 short tons to 40,000; imports dropped slightly from 49,000 tons to 48,000; and exports decreased from 1,400 tons to 1,000. Purchases of 97/98 percent carbon Ceylon amorphous lump graphite continued for the national stockpile.

No major increase in requirements for natural graphite is foreseen. Manufactured (artificial) graphite is used for nuclear reactor, guided missile, and similar new applications.

GYPSUM

By Leonard P. Larson, Commodity Specialist
Branch of Construction and Chemical Materials

The major expansion programs initiated by several producers in the previous year or two continued into 1956, but demand failed to materialize as rapidly as anticipated.

Domestic production of crude and calcined gypsum, totaling 10.7 and 8.7 million short tons, respectively, declined 3 percent from the previous year's record high. Consumption of most categories of gypsum-building products, particularly the high-value prefabricated materials, followed the downward trend of residential building from the high level reached in 1955. The volume for most gypsum products although lower than in 1955, was greater than in any other previous year. Sales of sheathing and formboard increased, whereas decreases were reported for gypsum lath, wallboard, laminated board, and tile. Nonresidential construction activity increased, and industrial plasters were in high demand. The market for uncalcined gypsum products also was strong.

Owing to the continued decline in new residential construction, the production of gypsum and gypsum products used in home construction is expected to decline in 1957. The industry anticipates that nonresidential and public construction will remain strong, helping to offset the decline in residential demand.

IRON ORE

By Horace T. Reno, Assistant Chief
Branch of Ferrous Metals and Ferroalloys

The marked trend for domestic operators to concentrate iron ore before shipment continued, and 60 percent of the crude ore mined was shipped to beneficiation plants. Production of iron from Minnesota's huge taconite resources was highlighted by formal dedication of the Reserve Mining Co. E. W. Davis plant at Silver Bay on September 23. This plant achieved capacity output of taconite pellets in the latter half of 1956.

Domestic iron ore production in 1956 was retarded by a 35-day steel strike from July 1 to August 3 and a 5-week local strike of Great Lake fleet ships' officers. However, domestic mines produced almost 100 million tons of usable ore, and extension of the Great Lakes shipping

season to December 21 permitted most of it to reach consuming centers. Imports comprised 24 percent of the total domestic supply, as iron ore imports reached a new alltime high—30 percent more than the record established in 1955.

As the result of availability of large quantities of fine-grained, high-grade iron concentrate from taconite and jaspilite beneficiation plants, much interest was demonstrated in investigating possible processes for reducing iron ore fines directly with low-cost gases. Use of the fluidized solids technique, which originated in the oil industry in the late '30's, gave promise of developing a reduction process that in some areas might compete economically with the blast furnace for treating iron ore containing few impurities.

KYANITE

By Brook L. Gunsallus, Commodity Specialist
Branch of Ceramic and Fertilizer Materials

United States imports for consumption of massive high-grade kyanite decreased 8 percent in 1956 from 1955, mainly because of the availability of synthetic mullite comparable in quality and price to that produced from imported kyanite. Production of domestic kyanite concentrate continued by Commercialores, Inc., near Clover, S. C., and Kyanite Mining Corp., near Farmville, Va.

LEAD

By O. M. Bishop, Commodity Specialist
Branch of Base Metals

Stable prices and good industrial demand, supplemented with Government purchases of lead for the national stockpile, stimulated both the largest smelter-refinery output since 1942 and a moderate increase in domestic mine production. The total lead supply (1,320,000 tons) was derived from domestic mine production (26 percent), imports (35 percent), and secondary sources (39 percent). Domestic consumption approximated 1,190,000 tons, and exports accounted for about 5,000 tons.

The quoted price of common lead, New York, averaged 16.01 cents, well above the 15.14 cents of 1955 and 14.05 cents of 1954. In response, mine output of recoverable lead in the United States increased 10,000 tons to 348,000 tons in 1956. Missouri was the leading lead-producing state for the 49th consecutive year, contributing 35 percent of the total domestic output. Idaho, with 18 percent, ranked second; and Utah, with 14 percent, ranked third. Other producing states, in the order of their production, were Colorado, Montana, Oklahoma, Arizona, Washington, California, Kansas, Nevada, New Mexico, Illinois, Virginia, Wisconsin, New York, and Oregon.

Combined imports of pig lead, lead in ores and concentrates, and matte increased to 458,500 tons in 1956, compared with 441,600 tons in 1955 and 437,600 tons in 1954. Of the total imported during the year 262,000 tons was pig lead, principally from Australia, Mexico, Yugoslavia, Peru, and Canada. The 196,500 tons contained in ore and other forms was chiefly from Peru, Southwest Africa, Canada, Australia, and Bolivia.

Industry has expressed some concern at the moderate, but rather consistent decline in per capita consumption of lead, as contrasted to rising use of other common metals. Consumption in 1956 was 14.16 pounds of lead per person. The decline is attributed to lessened demand

for white lead in paint formulas, replacement of lead in sheathing cables by plastics and in some instances aluminum, substitution of copper and iron for lead water pipes, and replacement of chemical lead by plastics. These substitutions have been offset in part by increased demand for lead in tetraethyl lead antiknock fluid and increased quantities of lead for automotive batteries, owing to the manufacture of more and larger batteries. At present, industry is developing and expanding such relatively new uses as lead ceramic coatings on aluminum sheet and improved alloys for numerous uses, including bearings and battery grids. The unusual physical and chemical properties of lead, its softness and extreme workability, high specific gravity, alloying properties, low melting and high boiling points, corrosion resistance, impenetrability by shortwave radiation, and relatively low cost present many advantages that will continue to give it widespread and extensive industrial use.

LITHIUM

By A. E. Schreck, Commodity Specialist
Branch of Construction and Chemical Materials

Interest in lithium in 1956 continued high. Production and consumption of the minerals and compounds continued to increase, and three domestic lithium producers joined to form a research institute.

Production of lithium minerals was reported in Maine, North Carolina, and South Dakota, and dilithium sodium phosphate was produced from the brines of Searles Lake, Calif. A new lithium-chemical plant at San Antonio, Tex., which processed lepidolite imported from Southern Rhodesia, completed its first full year of operation. The American Lithium Institute, Inc., Princeton, N. J., was organized in late 1956 to conduct research on lithium and its compounds and to disseminate technical information.

Increases in capacity to produce lithium minerals, lithium metal, and chemical compounds were reported.

Interest in lithium deposits in Canada remained active, new claims were staked, and several firms reportedly planned to start mining operations. Spodumene concentrate produced in Quebec was exported to the United States for processing to lithium chemicals.

The outlook for the lithium industry is one of increased consumption in present uses, development of new uses and markets, and lower prices.

MAGNESIUM

By H. B. Comstock, Commodity Specialist
Branch of Light Metals

A number of new peacetime uses for magnesium were noted in 1956. The automotive industries reported new applications of magnesium die castings and die forgings. By the close of 1956 new magnesium alloys were in service in aircraft in areas reaching 800° F., and subjected to intense vibrational stresses. The satisfactory performance of these new alloys prompted design engineers to select a magnesium alloy for the outer shell of the first earth satellite. The use of primary magnesium as a reducing agent to produce other metals rose 65 percent above that in 1955. Although production of primary magnesium in 1956 increased 12 percent above 1955, the rate of consumption had risen to the point early in the year, that the need for additional commercial production capacity was considered. In July 1956 the Alabama Metallurgical Corp.

announced that it had obtained a plant site at Selma, Ala., to build a 10,000-ton silicothermic plant to produce magnesium from a large dolomite deposit nearby.

As in 1955, all commercial production of primary magnesium was by the Dow Chemical Co. at its electrolytic plant at Freeport, Tex., and at the Government-owned, Dow-operated electrolytic plant at Velasco, Tex. The price of domestic primary magnesium increased twice in 1956, bringing it to 35.25 cents per pound, which was 2.75 cents above the price at the close of 1955. During 1956 exports of magnesium fell 4,842 tons below 1955, and imports fell 1,214 tons. In June 1956 tariff rates on magnesium were lowered. Duty on the metal pig and alloys fell from 20 cents to 17.2 cents per pound; and on the magnesium content of powder, sheets, tubing, manufactures, etc., duty fell from 20 cents per pound plus 10 percent ad valorem, to 19 cents per pound plus 10 percent ad valorem.

MANGANESE

By G. L. DeHuff, Jr., Commodity Specialist
Branch of Ferrous Metals and Ferroalloys

Final figures show that 345,000 short tons of manganese ore containing 35 percent or more manganese was produced in the United States in 1956. This exceeded, by a small margin, the Nation's production for 1918, thus establishing an alltime record. In addition, the Government continued to receive both high- and low-grade manganese ores under it Butte-Philipsburg domestic manganese-purchase program at approximately the same rate as in 1955; these ores will not be reported as production until they are shipped from the depots as usable ore or concentrate.

The quota for the Government's carlot purchase program for Metallurgical-grade ore was increased June 30 from 19 million to 28 million long-ton units of contained manganese, and the terminal date was advanced to January 1, 1961. Western states contributed 73,000 short tons to this program in 1956, as compared with only 8,100 in 1955 and 1,300 in 1954. Mines in Arkansas, Tennessee, and Virginia continued to provide substantial quantities to the Government under the program, and Georgia was also a contributor. The Nevada production of nodules by Manganese, Inc., sold to the Government under special contracts, composed about one-third of the Nation's ore production, and the nodules produced by the Anaconda Co. from its Montana carbonate ores ranked next in importance. Manganese Chemicals Corp. produced synthetic battery ore and a high-purity manganese carbonate from low-grade Cuyuna range (Minn.) material, while Trout Mining Division of American Machine and Metals, Inc., continued to produce battery concentrate from its Philipsburg, Mont., ores.

The symposium on manganese deposits, 20th International Geological Congress, held in Mexico City, received many worthy papers. The Bureau of Mines continued its program of examining domestic manganese deposits and DMEA its assistance in their exploration. Both industry and the Bureau continued research on the recovery of manganese from low-grade and off-grade materials.

United States imports of manganese ore for 1956 totaled 2,235,000 short tons, with India, Union of South Africa, Gold Coast, Brazil, and Cuba the chief sources of supply, in that order. In addition, 244,000 short tons of ferromanganese was imported. Ore consumption for the

year was a record 2,243,000 short tons, leaving industrial ore stocks of 1¼ million short tons at the year end. High ocean freight rates caused by closing of the Suez Canel, high demand, reimposition of the Indian export tax, and entry of the Indian State Trading Corp. into the manganese-ore business drove quoted prices for Indian ore of 46- to 48-percent manganese content to a nominal high in December of $1.69 per long-ton unit of manganese, c.i.f. United States ports, import duty extra, Indian export duty included.

Present indications are that both domestic production and imports of manganese ore will be higher for 1957, with consumption at about the same level. The current year is expected to be a busy one for the commodity in all other respects.

MERCURY

By James W. Pennington, Assistant Chief
Branch of Base Metals

Mercury production at domestic mines in 1956 was at the highest rate in 10 years and exceeded 1955 by nearly 30 percent, as a result of new and expanded operations. Consumption of mercury also rose in most uses, but due to less metal being required for new chlorine and caustic soda installations, total consumption declined 5 percent from the preceding year. This strong industrial demand, including the rebuilding of inventories, pushed general imports up to more than double 1955 receipts.

Following removal of quantitative export controls in the last quarter of 1955, exports and re-exports of mercury gained significantly during 1956. Despite a constant mercury price in the last 6 months of 1956, the decline in the first half of the year was enough to lower the yearly price 10 percent from the alltime peak established in 1955.

Government assistant was continued during the year in the Defense Minerals Exploration Administration's program and the General Services Administration's guaranteed-price program.

World output of mercury topped all yearly rates since 1943, as gains in Italy, Japan, the Philippines, Spain, and the United States more than offset losses in Mexico and Yugoslavia.

With extension of GSA's purchase program to the end of 1958 and continued activity in the exploration and development of new operations, mercury production both in the United States and the world should increase. Consumption of mercury should also continue high and possibly increase, as plans have been announced for new chlorine and caustic soda installations, and potentially large new uses of mercury in pigments and as a catalyst in the manufacture of methyl styrene have been reported.

MICA

By Milford L. Skow, Commodity Specialist
Branch of Ceramic and Fertilizer Materials

Production of mica for sale to the Government under the purchasing program for domestically produced block, film, and hand-cobbed mica continued at a high level. The program, to expire June 30, 1957, was extended to June 30, 1962, or until total purchases are equivalent to 25,000 short tons of hand-cobbed mica. Cumulative purchases at the end of 1956 were equivalent to 10,000 short tons of hand-cobbed mica. Government prices were raised for some sizes, and qualities of full-

trimmed mica and Government charges for processing hand-cobbed mica were increased.

At Greeneville, Tenn., International Minerals & Chemical Corp. began producing ground mica from the silt behind TVA's Nolichucky Dam. Petaca Mining Corp. increased the capacity of its plant near Santa Fe, N. Mex., to 60 tons of dry-ground mica daily.

In 1956 domestically produced muscovite mica sold to GSA totaled 143,000 pounds of full-trimmed and 1.9 million pounds of hand-cobbed mica. Sales of punch mica to industry declined to an estimated 350,000 pounds, compared with 380,000 in 1955. Sales of ground mica remained at about the 106,000-short-ton level of 1955. Imports of block and film were each about 14 percent greater than in 1955, but imports of splittings declined almost 20 percent. Compared with 1955, about 7 percent less block and film and 4 percent less splittings were fabricated.

Continued growth of the electronic and electrical industries and the increasingly severe requirements of materials kept the demand for sheet mica at a high level. Changes in design and fabrication of various electrical appliances have displaced some lower qualities of block mica, and slowly increasing use of mica paper in place of builtup mica has lessened the demand for splittings. Despite the improvement and increasing use of transistors and various nonmica capacitors, demand for the higher qualities of block and film mica continues to increase. Synthetic mica, although not yet a substitute for strategic grades and qualities of block and film natural mica, was used increasingly for glass-bonded mica products.

MOLYBDENUM

By Wilmer McInnis, Commodity Specialist
Branch of Ferrous Metals and Ferroalloys

Domestic production of molybdenum in 1956 was 7 percent less than the peacetime record output of 1955, although mining and milling capacity increased, and demand exceeded supply. The principal factor contributing to the decline in production was the lower average grade of ore treated.

At the Climax mill a new unit increased milling capacity 4,000 tons a day, but production declined because of the necessity (in 1956) of mining ore of lower average grade. Byproduct molybdenite concentrate was reported for the first time from the San Manuel and from the Silver Bell copper mine, both in Arizona.

Molybdenite ores ranged in grade from 0.3 to 2.0 percent, and the molybdenite (MoS_2) content of copper and tungsten ores ranged from about 0.01 to 0.08 percent. Colorado, Utah, Arizona, New Mexico, California, and Nevada, in that order, supplied all United States production.

United States consumption and foreign demand were both greater than in 1955, and scheduled deliveries to the Government were diverted to industry to alleviate shortages. There were no imports during the year. Consumption of molybdenum in the United States, excluding scrap, was about 92 percent in alloys, 3 percent as pure molybdenum, and 5 percent in nonmetallic applications.

Prices of molybdenite concentrate increased on August 25 by about 7 percent to a price per pound of $1.18 f.o.b. Climax, Colo., and $1.23 f.o.b. Washington, Pa.

Molybdenum was in critical short supply in some countries at the year end, and the outlook was for continued increase in demand both in the United States and abroad. Molybdenum has certain properties that are desirable in high-temperature applications but also tends to oxidize at high temperatures. Considerable research was directed toward solving this oxidation problem, which if successful would lead to wider use of molybdenum.

NICKEL

By Hubert W. Davis, Commodity Specialist
Branch of Ferrous Metals and Ferroalloys

The supply of nickel continued to be adequate to satisfy both civilian and defense needs in 1956. As a result, intensive activity continued in exploring for new sources, developing new mines, expanding and increasing efficiency of smelting and refining facilities, and searching for substitute materials.

Free-world production of nickel (231,000 short tons) and United States consumption (127,600 tons) and imports (142,600 tons) established new highs. The record consumption resulted chiefly from diversion to industry of 77.5 million pounds of nickel from scheduled shipments to the Government stockpile. Although domestic production, chiefly in Oregon and Missouri, increased 76 percent over 1955 to establish a new record of 6,700 tons, it was equivalent to only about 5 percent of consumption in the United States in 1956.

A revised expansion goal aimed at providing the United States with an annual supply of 440 million pounds of nickel by 1961 was announced by the Office of Defense Mobilization on May 17, 1956. Chiefly as a consequence, expansion and development programs under way or planned, mainly in Canada and Cuba, were scheduled to raise the free-world nickel production to at least 650 million pounds annually by the end of 1961.

Subsequently, the International Nickel Co. of Canada, Ltd., announced that it would develop in the Mystery-Moak Lakes region in the Province of Manitoba the world's second largest nickel-mining operation. Full capacity production was expected to be attained in 1961. Freeport Sulphur Co., which completed favorable pilot-plant tests on a new process for producing nickel and cobalt from laterite deposits at Moa Bay, Cuba, announced that it would build a commercial plant at Braithwaite, La., with an annual capacity of 50 million pounds of nickel and 4.4 million pounds of cobalt. The 75-percent expansion of the nickel-producing facilities at the United States Government-owned plant at Nicaro, Cuba, was completed in March 1957. Capacity production was attained by Hanna Nickel Smelting Co. by placing two additional furnaces in commercial operation to treat ore from the deposit near Riddle, Ore. Although producing four times more nickel metal in 1956 than in 1955, the refinery of National Lead Co. at Fredericktown, Mo., did not attain capacity production. National Lead Co. began producing nickel metal from Cuban nickel oxide sinter at its new refinery at Crum Lynne, Pa.

Effective December 6, 1956, the contract price to United States buyers of electrolytic nickel in carlots, f.o.b. Port Colborne, Ont., was advanced $9\frac{1}{2}$ cents a pound to 74 cents, including duty of $1\frac{1}{4}$ cents.

PERLITE

By L. M. Otis, Commodity Specialist
Branch of Construction and Chemical Materials

The domestic production of crude perlite continued its annual increase, although output was only 4 percent greater in 1956 than in 1955, marking a reduction of the yearly rate of increase.

Uses for expanded perlite for 1956 were close to those in the previous year. Plaster aggregate, the principal market, consumed 77 percent against 76 percent during 1955. The next largest market, concrete aggregate, increased from 10 percent in 1955 to 13 percent in 1956. The other principal applications (for oil-well drilling muds and oil-well concrete, filter aids, and miscellaneous uses) were down slightly.

Although research is constantly developing new uses, most of them have been minor tonnagewise. Building construction consumed 90 percent of all perlite output in 1956, and therefore the future outlook for perlite sales is geared to trends in the building industry.

PHOSPHATE ROCK

By E. Robert Ruhlman, Commodity Specialist
Branch of Ceramic and Fertilizer Materials

Discovery of huge deposits of phosphate-bearing sands in Baja California, Mexico, and further expansion of the phosphate-rock industry in the western fields of the United States were reported during the year. Production was reported from the Centennial mine on the Montana-Idaho border. Reserves at Centennial were reported to total 30 million long tons. The Bureau of Mines continued its research to develop new methods and equipment for underground mining of phosphate rock.

The United States output of marketable phosphate rock in 1956 continued to come from Florida, Tennessee, Idaho, Montana, Wyoming, and Utah and totaled more than 15.7 million long tons, derived from over 52 million tons of ore. World production in 1956 (12 percent above the 1955 figure) totaled 33.5 million long tons.

Expanding demand for mineral fertilizers will require increased phosphate-rock output. Chemical uses will also need substantial tonnages.

PLATINUM-GROUP METALS

By J. P. Ryan, Commodity Specialist
Branch of Rare and Precious Metals

World production and United States imports and consumption of platinum-group metals reached new highs in 1956.

It is estimated that world output of platinum-group metals in 1956 was about 980,000 ounces, a 3-percent gain over 1955. Union of South Africa and Canada again supplied 82 percent of the total; virtually all of the remainder came from the Soviet Union, United States, and Colombia. Most of the United States mine production was recovered from Alaska placer deposits. Although the United States produced only 3 percent of the world output, it consumed over three-quarters in 1956.

Platinum and palladium were acquired by the Government through exchange of agricultural products to friendly countries by the Commodity Credit Corp. of the United States Department of Agriculture. Stocks held by refiners, importers, and dealers were slightly higher at the end of 1956 than on the corresponding date in 1955.

The major market for platinum continued to be the petroleum-refining industry, where the metal is used as a catalyst for producing high-octane gasoline. Palladium was used chiefly in manufacturing contacts for telephone relays and other electrical regulating equipment. A 15-percent increase in sales of palladium to consuming industries more than offset lower sales of other platinum-group metals, resulting in an overall gain of about 3 percent for the year.

Prices of platinum-group metals, which historically have been subject to wide fluctuations due to cartel control and speculation, remained remarkably stable during 1956. Except for a few weeks in the early part of the year, the platinum price quotation, per fine ounce, was steady at \$97-\$110 to the middle of May, then \$103-\$110 to August, and \$103-\$107 thereafter. Other platinum-group-metal prices per fine ounce remained unchanged as follows: Palladium, \$23-\$24; iridium, \$100-\$110; osmium, \$80-\$100; rhodium, \$118-\$125; and ruthenium, \$45-\$55.

A substantial increase in productive capacity by Rustenburg Platinum Mines, the world's largest producer of platinum, and announcement of further expansion by that company at its South African mines were outstanding developments of 1956. Another significant development was the announcement by the International Nickel Co. of plans for developing large platinum-bearing nickel deposits in Manitoba, Canada.

POTASH

By E. Robert Ruhlman, Commodity Specialist
Branch of Ceramic and Fertilizer Materials

The potash industry in 1956 was preparing to meet anticipated increased demand by expanding existing and developing new facilities in the United States and Canada. At least four domestic producers were exploring deposits in Canada, and one firm is expected to begin production in Canada in 1958.

In the United States the National Potash Co. (the sixth producer in New Mexico) had nearly completed its mine and refinery in Lea County, N. Mex., and the Farm Chemical Resources Development Corp. (the seventh producer) began developing a deposit, also in Lea County. The United States Potash Co. and the Pacific Coast Borax Co. merged to form the United States Borax & Chemical Corp.

United States and world production of potash both were about 4 percent greater in 1956 than in 1955 and totaled 2.1 and 8.3 million tons of K_2O equivalent, respectively.

RARE-EARTH METALS

By Charles T. Baroch, Acting Chief
Branch of Rare and Precious Metals

New uses for the rare-earth metals for atomic-energy purposes were strongly hinted and widely discussed in 1956, but few significant developments were reported. Supplies continued in overabundance, mainly resulting as coproducts of processing monazite for its thorium content.

Before 1956 production figures on monazite could not be revealed. Preliminary figures for 1956 indicate that domestic mine shipments of concentrates totaled slightly over 1.5 million pounds of contained rare-earth oxides (ReO), somewhat less than in 1955. Production, listed in order of importance, was from monazite mined in South Carolina and Florida, bastnaesite from California and New Mexico, and euxenite from Idaho. No shipments of monazite were reported from Idaho, but

concentrate was stockpiled awaiting more favorable economic conditions. Euxenite concentrate was shipped under Government contract by Porter Bros. Corp. of Boise to Mallinckrodt Chemical Works at St. Louis, Mo., where the columbium and uranium were extracted, leaving the rare-earth metals in a residue.

Davison Chemical Co., division of W. R. Grace & Co., announced a large expansion of monazite-processing facilities by absorbing Rare Earths, Inc., of Pompton Plains, N. J. A new plant was opened near Baltimore, Md., for processing monazite sand to produce separate thorium and rare-earth compounds. Monazite from the General Services Administration stockpile was used, supplying the AEC with the thorium, and returning the beneficiated rare-earth compounds to the stockpile.

Although the enthusiasm of recent years concerning the rare-earth metals declined, the feeling persisted that a breakthrough of important new uses in atomic energy may create a sudden sharp rise in demand.

SAND AND GRAVEL

By W. W. Key, Commodity Specialist
Branch of Construction and Chemical Materials

In 1956 sand and gravel was again the largest mineral industry tonnagewise. It also ranked among the leaders in dollar value. As the industry was beginning to feel the effect of the new Federal Highway program, output probably reached a record tonnage. In this period of growth of the sand and gravel industry, substantial technical progress is being made. Specifications are becoming increasingly stringent; consequently equipment and flowsheets are becoming more complex. Through improvement of technology and efficiency, the industry has maintained a relatively stable low-price structure in the face of advancing costs.

Output of sand and gravel in 1956 has been estimated at about 600 million tons, of which about 20 million was industrial sand. Over 4,200 plants were in production.

The sand and gravel industry is expected to continue to advance with expansion of total national construction. Although the outlook as a whole is optimistic, acute economic and technical problems confront the industry in many localities. Encroachment of residential areas, shortages of reserves, high transportation costs, technologic difficulties in meeting rigid specifications, and keen competition from crushed stone are some of the problems the industry faces.

SELENIUM

By Elmo G. Knutson, Commodity Specialist
Branch of Rare and Precious Metals

The alltime high in United States production, plus increased imports, eased the critical selenium supply situation in 1956. Total supply approximated 1,349,000 pounds, or 29 percent more than 1955. Consumption also reached a record.

Domestic output of selenium totaled 1,117,000 pounds in 1956, compared with 851,600 pounds in 1955. This 31-percent increase was due to greater copper production, higher overall recoveries, increased shipments of selenium-bearing lead flue dusts from Mexico, and a larger output of secondary selenium from rectifier scrap. Principal source was the anode slimes produced during electrolytic refining of blister copper.

Shipments of selenium increased from monthly average of 73,600 pounds in 1955 to 86,300 pounds in 1956, an increase of 17 percent. Even though shipments of selenium set near records in 1956, indications were that consumers were decreasing their stocks late in the year, probably because of the prevailing prices for the metal and availability of substitutes. Ultrapure silicon and germanium were substituted for selenium to a limited extent in rectifiers and a cadmium-mercury combination replaced selenium to some degree in the manufacture of pigments. Producers' stocks increased from 78,400 pounds at the beginning of the year to 191,000 pounds at the end of 1956. Imports from Canada averaged 19,300 pounds a month for the year.

The price of commercial-grade selenium increased from $10.50 a pound to a range of $13.50-$15.50 a pound, beginning February 1, 1956. High-purity selenium metal of 99.99-percent purity sold for $3.00-$5.00 a pound more than commercial grades during 1956.

SILVER

By J. P. Ryan, Commodity Specialist
Branch of Rare and Precious Metals

United States mine production and consumption of silver in the arts and industries remained nearly the same in 1956 as in the preceding year, 37.1 million and 100 million ounces, respectively.

About 83 percent of domestic output of silver came from four States—Idaho, Montana, Utah, and Arizona. Nearly two-thirds of the domestic output was recovered from base-metal ores; and virtually all the remainder was recovered from ores mined principally for silver or from gold ores.

World output of silver in 1956 was estimated at 230 million ounces, a 4-percent gain over the preceding year's production. Mexico, the leading producer, supplied 19 percent of the total world output, and the United States was second with 16 percent. A significant feature of the international silver markets in 1956 was an acceleration in the rate of return to the United States Treasury of silver loaned under Lend-Lease arrangements to foreign countries. Treasury free-silver stocks were increased to 87.4 million ounces with the return of Lend-Lease silver. Total Treasury stocks at the end of the year were 1,981 million ounces.

The New York open-market prices for silver were relatively stable during the year; they ranged between 90.826 and 91.625 cents an ounce, the narrow range in fluctuations being attributed largely to the influence of the fixed Treasury buying price for domestic production (90.505 cents an ounce) and its selling price (91 cents).

United States consumption of silver in the arts and industries and for coinage continued to exceed domestic production by a wide margin. World consumption also continued to exceed production; but if United States coinage, which was not part of the market demand, were eliminated from consumption figures, world production was nearly in balance with effective demand.

Imports, including 94.9 million ounces of Lend-Lease silver, reached a postwar high of 160.9 million ounces in 1956. Canada and Mexico continued to supply most of the imports outside of Lend-Lease returns.

Hearings were held early in 1956 on a bill, S. 1427, providing for the repeal of existing silver legislation; but the bill was tabled, and no further action taken by the Congress.

STEEL

By James C. O. Harris, Commodity Specialist
Branch of Ferrous Metals and Ferroalloys

To meet the ever-increasing demand for steel, the steelmaking industry added 5 million tons to its capacity during 1956 and established a new record capacity of 133.5 million tons.

The iron and steel industry exhibited a sustained interest in achieving a greater output from the installed blast furnaces through the increased use of sinter, a premium-grade product, and of higher grade foreign ores. The use of humidity control and limited oxygen enrichment of the air blast and high top pressures continued to be interesting developments.

Despite the 34-day steel strike, which was called on July 1, the Nation's 1956 output of pig iron and steel (75.0 and 115.2 million short tons, respectively) was only 1.8 million tons less than in the record year 1955. Except for the summer months, monthly steel production exceeded the 10-million-ton mark, and a new record of 11 million tons was established in October. Steel furnaces operated at 89.8 percent of capacity in 1956 compared with 93.0 percent in 1955, and the AISI production index for the year 137.2 (1947-49=100). The electric furnace, which included 545,000 tons oxygen-converter capacity, established a new record of 9.2 million tons, while open hearth and Bessemer both declined from 1955 to 102.8 million and 3.2 million tons, respectively.

Shipments of steel, including exports, in 1956, totaled 83.3 million tons, compared with the 1955 total of 84.7 million tons.

Although the automotive industry was again steel's largest consumer, the quantity of steel used was 4.6 million tons less than in 1955. Automotive units produced in 1956 and 1955 were 6.9 and 9.2 million, respectively. All other steel-consuming industries showed a slight increase in receipts, except agriculture and ordnance and other direct military applications. Exports of steel totaled 3,622,427 tons, slightly higher than in 1955.

Average weekly hours worked per employee in the steel industry during 1956 were 40.4 compared with 40.6 in 1955. The average number of employees for the year was 535,000 compared with 545,000 in 1955, and the average hourly wage was $2.52 in 1956 compared with $2.38 for the previous year. The average composite price of finished steel, as published by *Iron Age*, was 5.358 cents a pound, compared with 4.977 in 1955.

Although the steel industry is making strong efforts to increase capacity, this is not reflected in blast-furnace construction. However, additional capacity will be achieved through burden changes and other operating techniques. One company, which is increasing its steelmaking capacity 1 million tons, is planning a 25-percent increase in pig-iron output by using a blast-furnace burden consisting of 50 percent sinter. The increased use of sinter is becoming standard practice in the majority of the Nation's blast furnaces. By the end of 1957 sintering capacity will be 63 million tons, a 25-million-ton increase in 2 years.

Other techniques that may be used to increase pig-iron output are: Better preparation of ore charges, use of higher iron content ores from foreign sources, use of concentrates and agglomerates, use of oxygen, high top pressure, and humidity control. National Steel Corp. has been using oxygen-enriched air for its four blast furnaces since 1951. With 1.5-percent oxygen enrichment, pig-iron output was increased 7 percent; and, with 2 percent, output was increased 9 percent.

The H-Iron process of the Hydrocarbon Research, Inc., Trenton, N. J., offers interesting possibilities as a new source of iron units for the American iron and steel industry. This process employs the fluidized-bed technique, using hydrogen as the reducing agent. Ordinary steel-plant rolls form the reduced iron into shapes which are used as a melting stock for open-hearth and electric furnaces. H-Iron with only 75 percent of the oxygen removed is used in open-hearth furnaces to replace charge ore as well as being a substitute for scrap. Cost of operation per unit of metal is reported to compare favorably with the cost of iron and steel scrap.

The portable gas-fired scrap preheater developed by the Bureau of Mines to preheat scrap for top-charged electric furnaces has been adopted by at least one steel plant. This innovation, which greatly reduces the energy cost and heat time for electric-furnace steelmaking, was described at the 1956 AIME Electric Furnace Steel Conference.

A recent interesting development in German steelmaking is the rotating furnace, known as the "Rotor," developed at the Oberhausen works. In this cylindrical furnace, which rotates on its horizontal axis, high- or low-phosphorus molten pig iron is converted directly into steel. Refining and the necessary heat are accomplished with oxygen which is introduced through two separate controlled jets. One is introduced beneath the surface of the molten metal and the other into the furnace atmosphere. A furnace with a heat capacity of 60 tons is currently operating and a 100-ton furnace is under construction.

During the year a new process for making steel directly from iron ore in a cyclone, called the Cyclosteel Process, was announced by the British Iron and Steel Research Association. The process employs a preheater and a cyclone reactor. Powdered iron ore and powdered coal are fed into the fluidized-bed preheater and the iron ore is partially reduced by the exhaust gases from the reactor. The mixture then passes through jet nozzles into the cyclone reactor and spirals downward through the reduction and burning zones. Oxygen is introduced to remove carbon and phosphorus and convert the carburized iron to steel. A pilot plant is being erected in England to investigate further this process.

STONE

By W. W. Key, Commodity Specialist
Branch of Construction and Chemical Materials

The Federal road program in 1956 provided a new major market for crushed stone which is expected to be active for many years to come. Trends in 1956 road-building designs called for thicker base courses, wider pavements, improved shoulders, and more structures, all requiring more aggregate material. Aggregates specifications have grown increasingly complex, but crushed-stone prices have advanced relatively little in the past 25 years, indicating the value of technologic advances in stone production. In many instances stone producers are encountering

operating difficulties in suburban areas, due in part to zoning regulations. Sometimes it is necessary to move to a new location. The use of portable and semiportable plants has permitted small deposits occurring along the highway right-of-way to be utilized. Many crushed-stone producers have become engaged in auxiliary enterprises that increase the value of their output. Agricultural limestone, bituminized aggregates, concrete products, and roofing granules are among these auxiliary products.

Production of stone in 1956 increased to about 500 million tons, an alltime high. Stone is the second largest mineral commodity tonnagewise and has paced the demands created by construction and other consuming industries. The bulk of this tonnage was crushed stone. Dimension stone has important markets in the building and monumental trade, but it represented only a very small percentage of total production.

Although the industry faces such problems as the decline in building construction, these are counterbalanced in other markets and the outlook is favorable for the near future.

SULFUR

By L. P. Larson, Commodity Specialist
Branch of Construction and Chemical Materials

Demand for sulfur by domestic and foreign consumers was high in 1956, and production of Frasch sulfur reached a record total. Recovery of brimstone in the purification of natural and refinery gases continued to increase, with addition of several new installations. Sales of domestic Frasch sulfur were slightly lower than in the previous year, as deliveries to the domestic market were reduced. Sharply increased imports and consumption of Mexican sulfur at acid plants on the southern and eastern seaboard were reported. The Mexican sulfur industry developed rapidly and made a vigorous effort to establish outlets for its products. For the first time Mexican sulfur offered serious competition to American producers in the world market.

Output of Frasch sulfur in 1956 of 6,424,000 long tons was the highest in the industry's history, increasing 12 percent over the previous production peak reached in 1955. Sulfur recovered in liquid purification of gas also increased and reached a record total of 465,000 tons. As production of Frasch sulfur was high during the year and shipments from the mines declined from 5,839,000 tons in 1955 to 5,676,000 tons in 1956, stocks of Frasch sulfur increased from 3,181,000 tons to 3,935,000 tons in 1956. Exports increased by 43,000 tons despite increased competition from foreign producers.

During the coming year the domestic sulfur industry is expected to face increased competition from Mexican producers. On the other hand, continued growth of the market is anticipated.

TALC, SOAPSTONE, AND PYROPHYLLITE

By Donald R. Irving, Assistant Chief
Branch of Ceramic and Fertilizer Materials

For the second successive year the combined production of talc, soapstone, and pyrophyllite in the United States exceeded 700,000 short tons; in 1956 it reached an alltime high of over 736,000 tons, compared with 726,000 tons in 1955. Production was reported from 14 States in each year. Increases were reported in 1956 from Alabama, Georgia,

Montana, New York, North Carolina, Pennsylvania, and Texas; decreases were reported from Arkansas, California, Maryland, Nevada, Vermont, Virginia, and Washington.

The outlook is for continued high demand, with emphasis on expansion of ceramic and insecticide applications.

THORIUM

By James Paone, Commodity Specialist
Branch of Rare and Precious Metals

Thorium consumption for nonenergy purposes in 1956 was about 25 percent above usage in 1955. The increase was attributable to the increasing demand for high-temperature-resistant thorium-magnesium alloys for guided missiles and aircraft. The year saw the first purchase of reactor-grade thorium for generating electric power from nuclear energy.

Domestically, thorium was produced from monazite recovered from Florida and South Carolina black sands; some was also dredged in Valley County, Idaho. Four domestic plants produced thorium compounds from monazite concentrates.

The leading countries producing thorium ores were Brazil, India, and Union of South Africa. Some production was reported from Australia, Ceylon, Indonesia, Korea, and Malaya.

The price of thorium oxide with a purity of 97-99 percent ranged from $8.25 to $9.35 a pound, depending on the rare-earth content. A basic price of $43 a kilogram for high-purity thorium metal was established during the year.

Despite much speculation regarding the future of thorium as a nuclear fuel, it appeared that its brightest outlook was as an alloying material for high-temperature metals. The gas-mantle industry also remained strong and provided a good outlet for thorium in 1956.

TIN

By Abbott Renick, Commodity Specialist
Branch of Base Metals

The tin industry in 1956 was characterized by four significant developments:

1. The minimum and long-term national strategic stockpile objectives for tin were reached.
2. It was decided to dispose of the Longhorn tin smelter, at Texas City, Tex., with cessation of purchases of tin concentrate by the United States Government.
3. The International Tin Agreement was ratified.
4. The Egyptian-Suez crisis resulted in increased tin prices—101.26 cents a pound in 1956.

World mine production of tin was 179,600 long tons in 1956, little changed from the 179,900 tons in 1955. Malaya, the largest producer, supplied 34 percent of the total. Other major sources include Indonesia, Bolivia, Belgian Congo, Thailand, and Nigeria. Production in Malaya and Thailand was the highest since 1941. Bolivian production declined for the third successive year and was the lowest since 1939. No tin ore was mined in the United States in 1956.

World smelter production in 1956 was 181,400 long tons, unchanged from 1955. The tin-smelting plants of Malaya, the most important

sources of pig tin, supplied 40 percent of the total in 1956. The United States supplied about 10 percent of the total in 1956 and 12 percent in 1955.

World consumption of primary tin in 1956 rose 3 percent to 160,500 tons, the highest since 1941. The United States consumed 60,500 tons (59,800 in 1955), or 38 percent of the total in 1956 and 1955. Tinplate, the major use of primary tin, reached a new peak of 5.7 million short tons, 5 percent above the previous high in 1955.

In 1956 domestic imports of metallic tin declined 3 percent and represented almost 80 percent of the total tin imported. Receipts of tin in concentrate declined 17 percent and were the lowest since 1940.

TITANIUM

By Jesse A. Miller, Commodity Specialist
Branch of Light Metals

United States production of the major titanium commodities rose markedly in 1956, as output of rutile increased 41 percent, ilmenite 17 percent, titanium pigments 18 percent, titanium-sponge metal 97 percent, and titanium mill products 172 percent over the previous year. In addition, a number of producers of these products continued to expand capacity in anticipation of even greater demand.

In the spring of the year 1956 Electro-Metallurgical Co. began producing sponge metal from its new plant at Ashtabula, Ohio. This was the first plant in the United States to use sodium to reduce titanium tetrachloride, thus breaking away from the magnesium-reduction process in use by all producers already in operation. E. I. duPont de Nemours & Co., Inc., Wilmington, Del., and Titanium Metals Corp. of America, Henderson, Nev., scheduled expansions of their sponge-metal facilities independent of Government assistance. U. S. Industrial Chemicals Co. and Allied-Kennecott Titanium Corp. announced plans to become commercial producers of sponge. To pace increasing demands for mill products, the semifabricators of titanium metal undertook expansion programs that would almost triple the melting capacity of the industry. Output of sponge metal in 1956 was 14,600 short tons, and 5,180 tons of mill products was shipped to various users. Titanium-mill products were in tight supply during the year as a result of larger military requirements for jet aircraft. In civilian applications titanium metal was gaining acceptance; and standard pieces of equipment, such as pumps, anodizing racks, and heat exchangers, were being produced commercially.

Domestic production of ilmenite and rutile achieved new heights in 1956 with a reported output of 685,000 tons of ilmenite and 12,000 tons of rutile. Over half of the ilmenite came from New York, while Florida produced most of the rutile. Florida was also an important source of ilmenite and lesser quantities of this mineral came from Virginia and South Carolina. The only State, aside from Florida, that produced rutile was South Carolina.

The United States continued to be the world's largest consumer of ilmenite and rutile in 1956, inasmuch as it consumed 57 percent of the 1,789,400 tons of ilmenite produced and 38 percent of the 121,500 tons of rutile produced in the world. Most of the ilmenite was used in making titanium pigments, and the majority of the rutile was utilized in welding-rod coatings and for titanium metal. Domestic consumption

of rutile for titanium metal in 1956 exceeded the quantity used for all purposes in the previous year.

After a number of years of shortage, rutile at last was in plentiful supply, as evidenced by its downward price trend in 1956. Ilmenite prices went up slightly as demand increased for this mineral as a raw material for titanium pigments. As a result of economies effected through volume production, sponge-metal prices were reduced 20 percent to $2.75 per pound and mill-product price reductions averaged about 12 percent.

TUNGSTEN

By R. W. Holliday, Commodity Specialist
Branch of Ferrous Metals and Ferroalloys

Of foremost importance to the tungsten industry was completion, in mid-1956, of the Domestic Tungsten Purchase Program. This brought to a close the period of high prices and assured markets that had existed from the early days of the Korean War.

After a brief suspension of Government purchases, new legislation in July (1956) authorized the purchase, under Public Law 733, 84th Congress, of an additional 1,250,000 short-ton units of tungsten trioxide; the domestic mining industry was briefly stimulated, but funds were provided only to the early part of December, and Government purchase was again suspended. At the year's end a considerable segment of the tungsten-mining industry was still in operation, but with no assurance that Government purchases would resume or that industrial consumers could absorb the domestic output. Stocks held by producers multiplied threefold during the year. Prices for imported concentrate were quoted at $33.50 to $34.50 in January and at $27.25 to $27.75 per short-ton unit, duty extra, by the end of December. Base price paid by the Government for domestic concentrate was $63 in January and was quoted at $55 in December, although actual purchase was suspended.

Total United States production of 906,000 short-ton units in 1956 was only 9 percent less than in the peak year 1955. The 5 largest domestic mines supplied about 57 percent, and the next 28 largest 41 percent of total output. Scheelite comprised about 75 percent of the concentrate produced and came, for the most part, from tactite deposits of Nevada, California, and Montana. Hubnerite was produced in North Carolina, Colorado (the Climax mine), and Idaho (the Ima mine). Ferberite was produced in Boulder County, Colo.

Consumption of concentrate in 1956 of 571,000 units slightly exceeded that of 1955. Alloy steels consumed about 41 percent of total tungsten (including scrap), pure-metal uses about 13 percent, and carbides about 35 percent.

Total supply of tungsten far exceeded industrial demand. Domestic output went to the Government stockpile during several months of the year; and foreign concentrate, purchases under long-term contracts, went to the Government throughout 1956. Imports in 1956 virtually equaled those in 1955.

Because of its known properties tungsten was a subject of research by organizations seeking to develop materials for improved resistance to stress and oxidation at high temperatures. Gradual increase in consumption appears likely, and substantial increases may develop in the next few years.

URANIUM

By James Paone, Commodity Specialist
Branch of Rare and Precious Metals

Uranium made significant progress toward maturity in 1956. Speculation subsided, and efforts were concentrated on production to supply the raw material necessary for peaceful and defensive utilization of the atom on a long-range basis.

Uranium-ore production from about 1,000 domestic mining operations totaled 3 million tons and was expected to double within 3 years. About 6,000 tons of uranium oxide was produced from 12 mills representing a $50 million investment and having a total daily ore capacity of nearly 9,000 tons. Eight new mills costing $35 million, with a combined capacity of 4,025 tons a day, were to be completed by early 1958.

At the end of the year domestic ore reserves were estimated at 60 million tons, with an average grade of 0.25 percent U308. Over two-thirds of the total reserve is in the Ambrosia Lake-Grants area, N. Mex. Other States, in ranking order of reserve importance, included Utah, Colorado, Arizona, Wyoming, and Washington.

Production of nuclear weapons continued to provide a market for uranium, but added emphasis was given to long-range, peaceful uses of atomic energy. Civilian power reactors and research reactors were completed or under construction during the year, and others were planned; successful performance of the nuclear-powered submarines, *Nautilus* and *Seawolf*, resulted in contractual agreements for seven other nuclear powered submarines. Indeed, the future of uranium as a source of energy was reasonably assured in 1956.

Uranium production continued in Belgian Congo, Canada, Union of South Africa, France, Portugal, Australia, and Sweden. The Canadian uranium industry, with a reserve of 225 million tons of ore containing 238,000 tons of uranium oxide, was expected to be one of the principal mineral producers in Canada within 2 years; the Canadian Government contracted for the purchase, before April 1962, of uranium valued at nearly $1.5 billion.

Uranium, a scarce and sinister commodity a decade ago, emerged in 1956 as a mineral of worldwide economic importance and growing significance.

VANADIUM

By Phillip M. Busch, Commodity Specialist
Branch of Ferrous Metals and Ferroalloys

Production of vanadium as a byproduct of carnotite ores of the Colorado Plateau continued to exceed demand.

Vanadium pentoxide (V_2O_5) production in 1956 was 14 million pounds, about 7 percent greater than in 1955. Domestic consumption of vanadium in 1956 was 3,977,000 pounds (vanadium content), an increase of 17 percent over 1955. There were no imports of vanadium in 1956, but imports of ore and concentrate from Peru in 1955 totaled 184,737 pounds (vanadium content). Exports of vanadium in 1956 in various forms were about 2 million pounds (vanadium content), about 1 percent less than in 1955.

As long as the relationship exists in the mining and extraction of uranium-vanadium ores, supplies of vanadium in the near future will continue to be more than adequate for military and industrial requirements, as well as exports.

ZINC

By A. J. Martin, Commodity Specialist
Branch of Base Metals

Domestic smelter output of slab zinc reached a new alltime high of 1,056,000 tons in 1956; and consumption, although 10 percent less than the peak established in 1955, was still above 1 million tons and the second largest on record. The lower consumption in 1956 was due mainly to the cutback in production in the automobile industry, largest consumer of zinc die castings; and the 5-week steel strike, which interrupted many galvanizing operations. Imports of zinc at 771,000 tons, including slab zinc and zinc contained in ores and concentrates, were 14 percent larger than in 1955 and larger than in any previous year. Domestic mine production of recoverable zinc was 538,000 tons, 4 percent above that in 1955. Secondary zinc produced was about 300,000 tons in each of the two years.

The price of zinc, Prime Western grade, East St. Louis, advanced ½ cent a pound to 13.5 cents on January 6 and remained there through December, averaging 10 percent higher than in 1955. The stable price in the face of unusually large imports and the decline in consumption was maintained by Government purchases of domestically mined zinc for the long-term national stockpile and acquisition of surplus foreign zinc for the supplemental stockpile through the barter program under which surplus agricultural commodities were exchanged for strategic and critical minerals.

The principal zinc-producing States, in order of rank based on mine output, were Montana, New York, Idaho, Tennessee, Colorado, Utah, New Mexico, Oklahoma, Kansas, Washington, Arizona, Wisconsin, Illinois, and Virginia. Producers of less than 10,000 tons during 1956 were California, Nevada, New Jersey, and Missouri. Features of production during the year were the large gain in New Mexico (where activity in zinc mining had been greatly curtailed in the 3 preceding years), the growing and new record high output in Tennessee, the drop in New Jersey's production (caused by a strike) to the lowest annual output in more than 50 years, and New York's rise to second rank among the States in zinc output.

The domestic primary zinc smelters are in Arkansas, Idaho, Illinois, Montana, Oklahoma, Pennsylvania, Texas, and West Virginia. Primary slab zinc was also produced in an electrothermic zinc slag furnace at Herculaneum, Mo. The three leading States in slab-zinc production were Montana, Pennsylvania, and Oklahoma.

Of the 245,000 short tons of slab zinc imported in 1956, Canada supplied 48 percent, western European countries 29 percent, Mexico and Peru 10 percent, Belgian Congo and Australia 10 percent, and other countries 3 percent. Of the ores and concentrates imported (526,000 tons zinc content), Mexico, Canada, and Peru together furnished 89 percent.

The latest figures indicate that world production of slab zinc in 1956 increased 5 percent over the 1955 total of about 3 million short tons. Gains were reported in nearly all European countries, Belgian Congo, and Japan, while output in Australia, Canada, and Mexico showed only small variations from 1955.

Established world productive capacity for zinc in 1956 and potential new producing mines being developed and equipped during the year

support a forecast of an adequate supply of zinc over the next 10 years and probably for a much longer period. A number of the new mines that were being developed or that reached the productive stage in 1956 were in the United States and Canada. Among these were 1 at Friedensville, Pa., 4 in eastern Tennessee, 2 in Virginia, 2 in Wisconsin, and the extensive underground Northwest Project of the Anaconda Co. at Butte, Mont.; and, in Canada, several mines in New Brunswick, 2 in Ontario, and 1 in Manitoba. Greenland became a zinc- and lead-producing country in 1956 when the Nordic Mining Co. mine at Mestersvig, discovered in 1948, started commercial operation.

ZIRCONIUM AND HAFNIUM

By Glen C. Ware, Commodity Specialist
Branch of Rare and Precious Metals

Burgeoning demand for zirconium and hafnium metal and for zircon and its products kept production facilities under pressure throughout the year. Domestic output of ores and concentrates increased 50 percent over 1955; imports rose 7 percent, and 2,200 tons was drawn from stocks. Although the demand for metal was spectacular, it contributed little to the immediate increase in consumption because of limited facilities for metal production, but it stimulated the growth of industrial plants to produce and fabricate the metals.

The Atomic Energy Commission reopened the Bureau of Mines zirconium plant at Albany, Oreg., under contract with the Wah Chang Corp. of New York. Its capacity, more than 300,000 pounds a year, matched that of the Carborundum Metals Co. expanded 200,000-pound-per-year plant at Akron, N. Y. Wah Chang immediately began constructing a privately owned plant at Albany scheduled for production early in 1957. The AEC further contracted with 3 companies to deliver 1,100 short tons of reactor-grade zirconium per year for 5 years and to recover hafnium compounds as a coproduct for reduction to metal. Each contractor began constructing a plant with capacity in excess of its contract, and each expected to begin delivering metal after mid-1957.

There was a substantial increase in melting capacity and in ingot size (up to 2,200 pounds). Shapes were cast in vacuum furnaces and were extruded, notably cylinders for jacketing atomic fuel elements.

Metal prices reflected the effect of competition. Bids to produce reactor-grade zirconium were offered the AEC at figures less than one-half the current nominal price of sponge, despite a steadily rising cost of raw materials. Further cuts in the price of sponge are expected, with $3.50 a pound for commercial-grade sponge as an early objective. Hope of attaining this objective is heightened by the number of innovations incorporated in new plants, by integrating operations from handling raw materials to fabrication of shapes. With an assured supply of metal, industrial uses of zirconium are expected to expand widely as the price drops.

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FERRY BUILDING, SAN FRANCISCO

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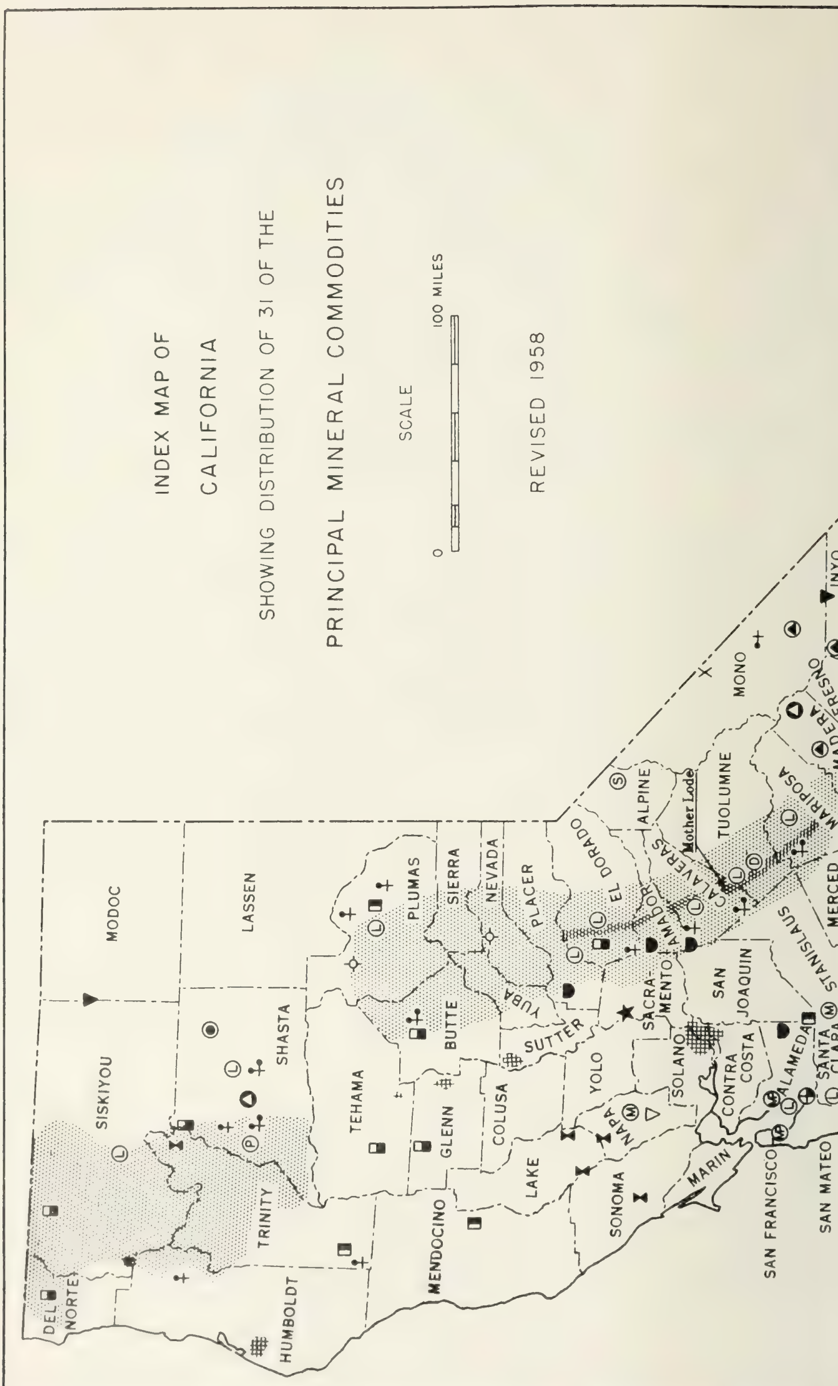
The Division of Mines maintains at its headquarters offices in San Francisco a technical library containing several thousand books and scientific journals on geology, mining, mineralogy, chemistry, metallurgy, and related subjects; a reading room containing periodicals devoted to the petroleum and mining industries, and newspapers from the mining centers of the state; exhibits of minerals, rocks, mine models, etc.; a service laboratory for the determination of California minerals; and a conference room with a mining engineer in attendance to serve the public and to sell publications of the Division. Publications are also sold at the Los Angeles, Sacramento, and Redding branch offices.

In addition to oral conferences in the offices of the Division of Mines, information concerning the mineral resources, mineral industry, geology, and mining operations of California is distributed to the public by means of publications, monthly releases, and letters. Each letter of inquiry received by the Division is answered by the technical staff member best qualified to do so.

The principal publications of the Division of Mines are **Bulletins**, **Special Reports**, and the quarterly **California Journal of Mines and Geology**, issued in January, April, July, and October of each year. **Mineral Information Service** is a monthly news release concerning the mineral resources and industry of California, designed to inform the public of discoveries, operations, markets, statistics, and new publications. A list of available publications will be sent free upon request.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CALIFORNIA
SHOWING DISTRIBUTION OF 31 OF THE
PRINCIPAL MINERAL COMMODITIES
SCALE
0
100 MILES
REVISED 1958
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
MENDOCINO
GLENN
BUTTE
SIERRA
NEVADA
COLUSA
YUBA
SUTTER
PLACER
LAKE
YOLO
EL DORADO
SONOMA
NAPA
SACRA-MENTO
AMADOR
ALPINE
SOLANO
MARIN
CONTRA COSTA
SAN JOAQUIN
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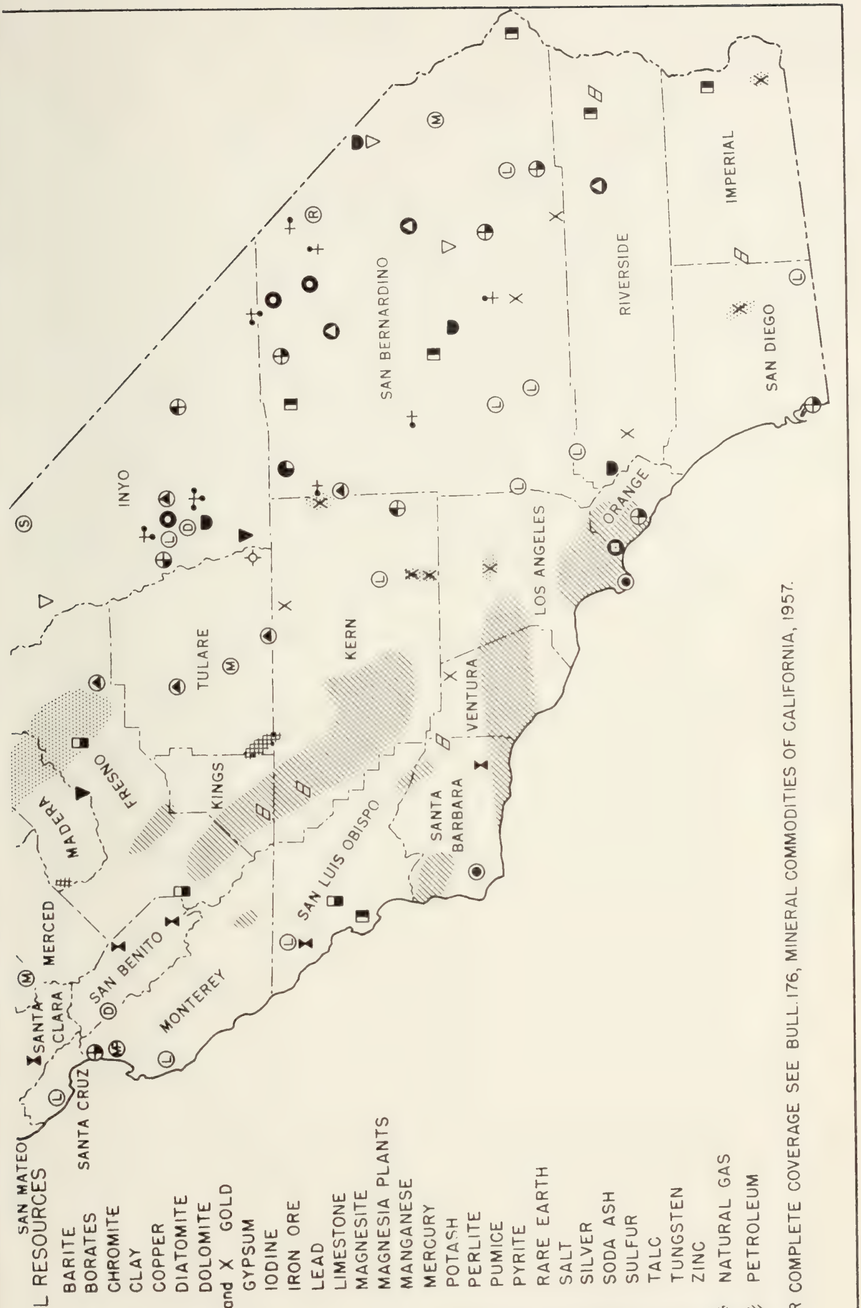

FOR COMPLETE COVERAGE SEE BULL. 176, MINERAL COMMODITIES OF CALIFORNIA, 1957.

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EFFECT OF MINERAL COMPOSITION ON STRENGTH OF CENTRAL-CALIFORNIA SEDIMENTS

By Robert B. Langston,* Parker D. Trask,* and Joseph A. Pask *

OUTLINE OF REPORT

Illustrations

ABSTRACT

In the course of an investigation of the fundamental geologic factors determining the strength of soils and soft sediments carried on under a contract with the Office of Ordnance Research, studies were made of the effect of clay composition upon the strength of 32 sediment samples from three boreholes near San Francisco. The depth of the boreholes ranged from 75 to 175 feet. The percentage of different clay minerals in these samples were determined by special techniques of X-ray diffraction whereby the intensity of reflections obtained from oriented specimens was compared with the intensity of reflections from similarly processed samples of known mineral content. The X-ray determinations were supplemented by differential thermal analysis studies. Complications were encountered because of the presence of several clay minerals in the samples. Illite was the principal type of clay mineral followed

* Member of Division of Mineral Technology, University of California, Berkeley, California. Manuscript submitted for publication July 17, 1957.

FIGURE 1. Index map showing location of boreholes in the San Francisco area.

in order by montmorillonite, chlorite, and kaolinite. The samples richer in montmorillonite—those containing 10 to 20 percent montmorillonite—tended to be relatively strong for a given water content and to have a higher plasticity index. The results of the experiments with these prototype sediments corroborate the findings of similar strength experiments using synthetic mixtures of known clay composition.

INTRODUCTION

The Office of Ordnance Research, Ordnance Corps, U. S. Department of the Army, in cooperation with the University of California at Berkeley has been conducting an investigation of the fundamental causes of strength in soils. Soil strength varies with many factors of which the more important are water content, clay composition, grain size, and sand-clay ratio. These factors to some extent are interrelated. The water content exerts such a dominant effect that studies of the effect of other factors should be considered in terms of samples of the same or similar water content. Previous studies of the effect of clay composition (Trask and Berge, 1956) in which synthetic sediments were formed in a settling tank have shown that sediments containing montmorillonite are appreciably stronger for a given water content than those consisting of illite or kaolinite. The effects of grain size and sand-clay ratio are presently being studied.

As the first phase of the investigation of synthetic or artificial soils in which the variables could be controlled, it seemed desirable to get an idea of the effect of clay composition on the properties of naturally occurring soft sediments. Accordingly a series of samples was obtained from brackish-water sediments in three boreholes in the neighborhood of San Francisco. The location of these boreholes is shown in figure 1. The first series is from San Francisco Bay in the vicinity of the proposed new crossing south of the present San Francisco-Oakland Bay Bridge; the second is from Sonoma Creek on the Sears Point Highway (State Highway No. 37) 30 miles north of San Francisco; and the third is from Elkhorn Slough, a few miles south of Watsonville on State Highway No. 1, 100 miles south of San Francisco Bay. The surface of all boreholes was at or slightly below sea level. The sediments were mainly clay, and presumably were saturated with water. The samples and sediment data, except clay composition, were supplied by the Materials and Testing Laboratory of the California Division of Highways, and by the California Division of San Francisco Bay Toll Crossings. Thanks are due to F. N. Hveem, A. W. Root, and Norman H. Raab for these courtesies.

In order to study the effect of clay composition upon strength of natural soils and sediments it was desirable to devise satisfactory methods of mineral analysis. The percentage of different clay minerals in these samples was in general determined by techniques of X-ray diffraction whereby the intensity of reflections obtained from oriented samples was compared with the intensities from similarly processed samples of known clay content. The X-ray studies were supplemented with differential thermal analysis (D.T.A.) measurements. Special techniques, described below, were developed to determine the percentage of different clay minerals in the samples.

DETERMINATION OF CLAY COMPOSITION

Clay mineral components, according to most theories concerning the nature of sediments, have been transported and altered by weathering agencies. This type of genesis naturally results in complex mineral assemblages.

The clay minerals can be classified into four main groups: namely, kaolinite, illite, chlorite, and montmorillonite. These groups have different lattice structures (Pask, 1956), and each group has varying degrees of isomorphous substitution. Throughout this report the term "mineral" represents a member of one of these four groups, whose composition is closely similar to other members of that group.

A satisfactory straightforward schematic system of analysis for the clay mineral components of a sediment has not yet been developed. The most frequently used means of identification are X-ray diffraction and differential thermal analysis. In analyzing the clay composition of sediments it is necessary, as a rule, to design and fit study methods to each particular type of sediment system.

Experimental Techniques

X-Ray Diffraction. In evaluating the clay mineral fraction and other components of a sample by X-ray diffraction analysis, workers have found it convenient to compare the intensities of certain reflections from an unknown material with the intensities of corresponding reflections produced by a reference mineral. A reference mineral is defined as one which the particular worker may have in pure or almost pure form.

In this study oriented samples were prepared by settling a small amount of minus 200 mesh material from a water suspension onto a glass slide to develop a density of about 20 mg per square inch. This concentration was found to give a minimum amount of screening so that the reflection intensities could be assumed to be proportional to the percentage of the material present. In interpreting the intensities, attention was given to the absorption and reflection coefficients of the materials. After air drying, the oriented samples were subjected to different treatments described below, and the resulting X-ray diffraction patterns were used to estimate the type and amount of minerals present.

The literature contains many examples of procedures that have been used for the identification of different components in various combinations of clay mixtures. Kaolinite in the presence of chlorite, mica in the presence of illite, chlorite in the presence of mica, and montmorillonite under various conditions have been discussed in recent papers by W. F. Bradley, G. Brown, R. E. Grim, and W. D. Johns. Some of these papers are listed in the bibliography.

The clay minerals have certain lattice spacings as well as other characteristics that allow their individual identification. Although some minerals have similar lattice spacings, it is usually possible to identify the individual clay types by studying their reactions to heating and chemical treatment. In the present work, X-ray diffraction patterns were obtained after subjecting prepared oriented samples to each of the following treatments: (a) air drying at room temperature; (b) glycolation (Brunton, 1955)—exposure to ethylene glycol fumes for 2

hours at 60° C in an aluminum desiccator; (c) firing to 450° C at a rate of 200° per hour in a muffle furnace, followed by air quenching; and (d) firing to 600° C at a rate of 200° per hour in a muffle furnace, followed by air quenching.

Differential Thermal Analysis. Samples were heated at a rate of 12° C per minute (Pask and Warner, 1954) so as to measure the dif-

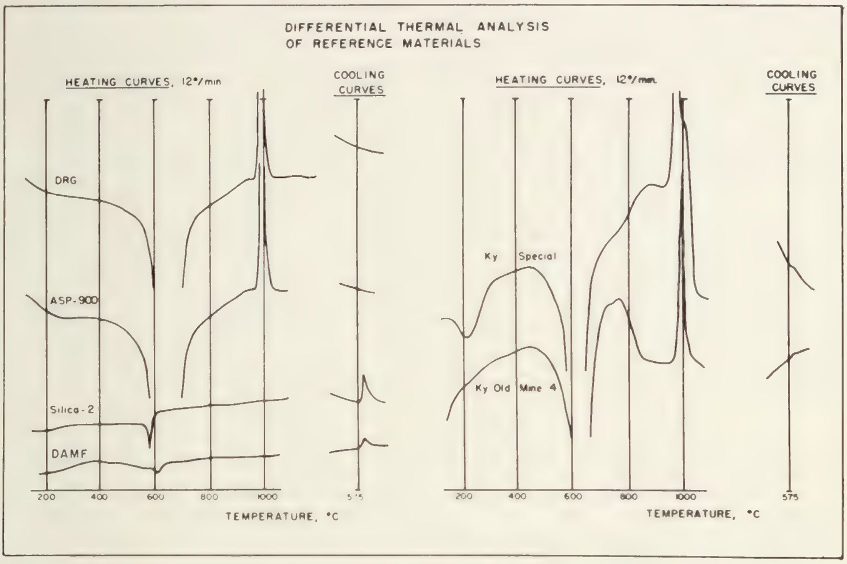

FIGURE 2. Differential thermal analysis of reference materials: DRG and ASP-900, kaolins; Kentucky Special and Kentucky Old Mine No. 4, ball clays; Silica No. 2, quartz; and DAMF, quartz and feldspar. Feldspar does not show any D.T.A. peaks; it thus acts as a diluent.

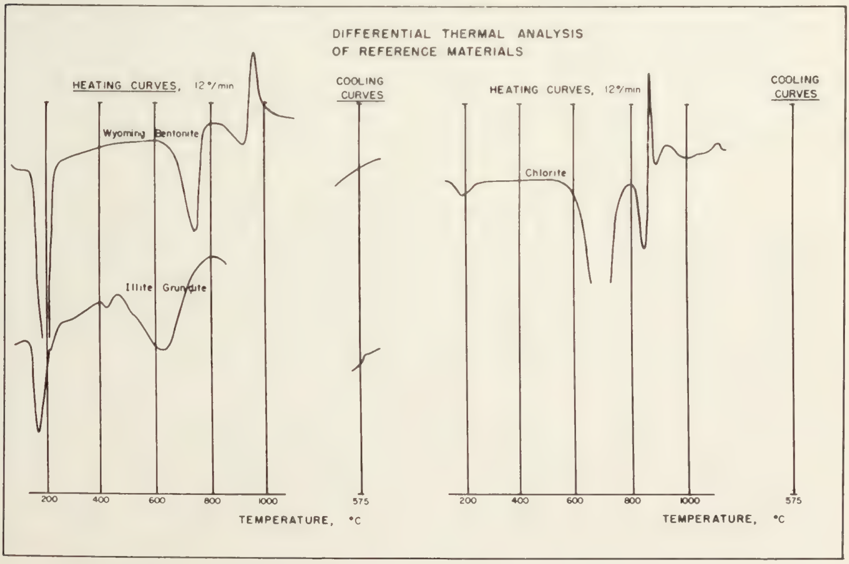

FIGURE 3. Differential thermal analysis of reference materials: bentonite, illite, and chlorite.

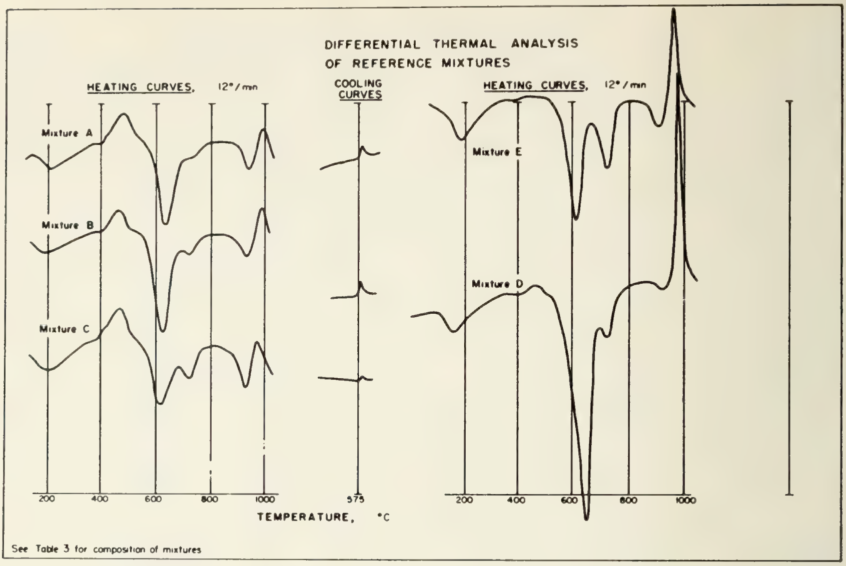

FIGURE 4. Differential thermal analysis of reference mixtures.

ferences in temperature between the sample and a standard inert material. Such differences indicate either an endothermic or an exothermic reaction. In the thermographs presented in figures 2, 3, and 4, upward deviation from the base line is the result of an exothermic reaction, while downward deviation is the result of an endothermic reaction. The base line from left to right represents the furnace temperature.

Base-Exchange Capacity. Ammonium ions were exchanged onto 4 or 5 gm samples by washing several times with neutral normal ammonium acetate solution. Excess ammonium salt was removed with 15 to 20 decantation washes of 70 percent isopropyl alcohol in water. The residual ammonium ions exchanged onto the sample were then determined by the Kjeldahl distillation method. Base-exchange capacities are reported as milliequivalents (meq) per 100 gms of clay solids.

Experimental Materials and Measurements

Three groups of samples were examined. The first group consisted of the raw materials used by Trask and Berge in 1956 in the preparation of their synthetic sediments. These materials were (1) Silica No. 2, which is ground quartz, (2) Grundite, composed mainly of illite and of minor amounts of quartz, (3) DAMF, a ground material having a median diameter of 1.2 microns, composed of quartz and feldspar, (4) Wyoming Bentonite, a montmorillonite, (5) Sierralite, a chlorite, (6) ASP-900, (7) DRG Clay, (8) Kentucky Mine Special and (9) Kentucky Old Mine No. 4. The last four samples are kaolinitic in composition. Table 1 shows the mineral composition of these materials as estimated from the X-ray diffraction and base-exchange capacity data. The X-ray diffraction studies on these materials also established certain mineral characteristics that were used in their identification. These

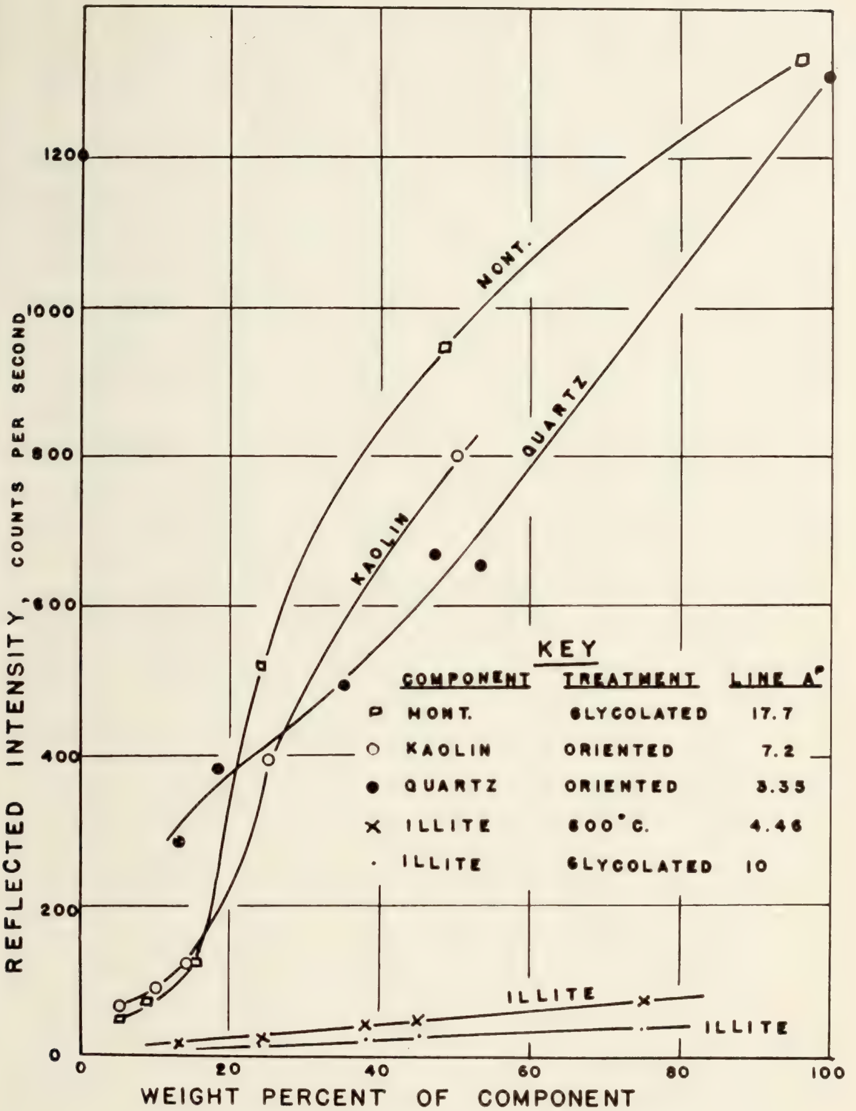

FIGURE 5. Effect of reference-mineral concentration on intensity of X-ray reflections.

*Table 1. Mineral composition of raw materials.***

Sample	Base-exchange capacity (milliequivalents per 100 grams)	Quartz	Chlorite	Feldspar	Illite	Montmorillonite	Kaolinite
Silica No. 2	1.1	100					
Sierralite	7.3		100				
DAMF	5.2	40		60			
Grundite*	18.0	22			75		
Wyoming Bentonite	78.0	4				96	
DRG Clay	2.3						100
ASP-900	3.9						100
Kentucky Mine Special*	12.9	20			10		70
Kentucky Old Mine No. 4*	10.0	12			6		80

* Also contains organic material.
** Composition estimated in weight percent.

Table 2. X-ray diffraction characteristics used for mineral identification.

Mineral	Sample studied	Characteristics	Lines used for quantitative estimation
Quartz	Silica No. 2	3.35 Å and 4.29 Å spacings are not affected by any treatments. (573° C. inversion on cooling is readily observed by D.T.A.)	3.35 Å line on oriented sample.
Feldspar	DAMF	Sample contains about 40% quartz. Heat treatments and glycolation do not affect the lattice constants, d = 3.5 and 4.29 Å for quartz and d = 3.20 Å for the feldspar.	3.20 Å line on sample fired at 600° C.
Chlorite	Sierralite	Lattice constants of d = 14.5, 7.2, 4.75, and 3.49 Å are not changed by glycolation and 450° C. firing. After the 600° C. treatment the 14 Å reflection is greatly increased and the other reflections are no longer observed.	14 Å (and sometimes 12 Å) line after 600° C. firing.
Illite	Grundite	10 Å and 4.46 Å peaks are not shifted by glycolation and heat treatments but the peaks are more intense and sharp. Grundite contains quartz and was estimated to contain 75% illite by difference.	10 Å line on glycolated sample, 4.46 Å line on sample fired at 600° C.
Montmorillonite	Wyoming Bentonite	Wyoming Bentonite contains about 4% quartz. The c-lattice dimension varies with the amount of moisture or other molecules between the layers.	12.6 Å spacing on oriented sample that expands to 17 Å upon treatment with ethylene glycol vapor at 60° C.
Kaolinite	DRG Clay	Strong reflections are present at d = 7.2, 4.45, and 3.58 Å. These lines are not affected by glycolation or 450° C. heat treatment, however, all 3 lines are destroyed by the 600° C. firing.	7.2 Å spacing on oriented sample.

*Table 3. Composition of prepared samples used as reference mixtures.**

Component	Mixture A	Mixture B	Mixture C	Mixture D	Mixture E
Quartz	47	53	35	13	18
Illite	38	24	45	13	9
Montmorillonite	5	9	15	24	48
Kaolinite	10	14	5	50	25

* Composition in weight percent.

characteristics are summarized in table 2. Figures 2 and 3 present thermographs of these materials.

After determining the purity of the samples in Group 1, some of the samples were selected as reference minerals. From these, the second group of samples was prepared from reference minerals, making compositions comparable to natural sediments. Table 3 summarizes the mineral composition of these prepared samples. Figure 4 presents thermographs of these prepared mixtures and figure 5 presents relationships observed between reference mineral composition and intensity of characteristic X-ray reflections. Average curves drawn through the appropriate experimental points served as calibration curves; the actual points indicate the experimental scatter.

The third group of samples consisted of specimens obtained from core holes drilled in preparation for highway and bridge construction programs, mentioned earlier and shown in figure 1. Samples 1 to 12 (table 4) are from San Francisco Bay and are from depths ranging from 18 to 176 feet. The P-1 series of samples (table 5) was taken in Sonoma County along the Sears Point Cutoff Highway (State Highway No. 37) and ranges in depth from 4 to 75 feet. The D-7 sequence (table 6) is from Elkhorn Slough on the proposed new highway from Watsonville to Castroville in Monterey County (State Highway No. 1) and ranges in depth from 4 to 109 feet.

Reference Minerals and Prepared Reference Mixtures

Quartz. The Silica No. 2 sample was assumed to be 100 percent quartz as neither X-ray diffraction nor differential thermal analysis disclosed any impurities. No change in lattice spacings was observed due to glycolation or heating treatments. The Silica No. 2 sample was thus adopted as the quartz reference mineral. Its base-exchange capacity was found to be 1.1 meq per 100 gms. Both the reflected intensity of the 3.35 Å line of the oriented sample shown on an X-ray diffraction pattern and the shape of the area under the peak at the 573° C exothermic reaction point on the D.T.A. cooling curve showed this sample to be satisfactory as a reference for estimating the amount of quartz present in an unknown sample.

Chlorite. The Sierralite sample's D.T.A. curve is typical for the chlorites. Its base-exchange capacity was found to be 7.3 meq per 100 gms. X-ray diffraction studies show the oriented, glycolated samples fired at 450° C to have strong reflections at 14.5, 7.2, 4.75, and 3.49 Å

Table 4. Core specimens from San Francisco Bay.

Sample	Depth (feet)	Base-exchange capacity milli-equivalents per 100 grams	Composition*							
			Differential thermal analysis quartz	X-ray quartz	Feldspar	Montmo-rillonite	Illite	Chlorite 14 Å	Chlorite 12.3 Å	Kaolinite
1	25	16	8	8	4	3	20	3	2	--
2	88	34	8	6	3	10	20	2	--	--
3	118	24	4	4	4	4	15	2	--	--
4	55	19	14	14	6	6	40	3	1	--
5	85	30	2	4	6	8	40	1	1	--
6	18	15	17	12	3	5	45	4	2	--
7	68	25	6	8	9	6	20	4	--	--
8	105	22	13	10	7	6	50	3	1	--
9	114	34	8	8	10	14	40	--	1	--
10	125	29	6	12	9	6	40	7	2	--
11	144	18	30	50	20	4	15	0.5	--	--
12	176	26	20	15	6	6	25	1	--	--

* Equivalent weight percent of reference minerals.

Table 5. Core specimens from Sonoma County.

Sample	Depth (feet)	Base-exchange capacity milli-equivalents per 100 grams	Composition*							
			Differential thermal analysis quartz	X-ray quartz	Feldspar	Montmo-rillonite	Illite	Chlorite 14 Å	Chlorite 12.3 Å	Kaolinite
P-1—1A	4	20	8	12	5	2	30	2	1	--
P-1—2A	9	28	2	10	5	3	40	4	2	--
P-1—4A	17	21	7	16	7	7	65	5	2	--
P-1—5A	23	20	12	14	7	3	25	3	2	--
P-1—6A	33	23	5	10	6	3	40	5	3	--
P-1—7A	43	17	8	12	8	4	55	4	--	--
P-1—8A	53	20	5	7	7	4	50	7	--	--
P-1—9A	68	17	11	9	7	6	30	4	2	--
P-1—10A	75	18	8	9	9	6	30	6	3	--

* Equivalent weight percent of reference minerals.

Table 6. Core specimens from Elkhorn Slough near Watsonville, Monterey County.

Specimen	Depth (feet)	Base-exchange capacity (milli-equivalents per 100 grams)	Composition*							
			Differential thermal analysis quartz	X-ray quartz	Feldspar	Montmo-rillonite	Illite	Chlorite 14 Å	Chlorite 12.3 Å	Kaolinite
D-7— 1A	4	37	None	--	-		--	--	--	--
D-7— 2B	8	36	2	13	11	9	75	7	5	--
D-7— 3B	13	20	3	15	9	11	60	5	--	--
D-7— 4B	19	28	6	12	7	10	55	-	--	1
D-7— 6A	29	36	None		--		--	--	--	--
D-7— 8A	40	14	15	17	8	4	30	--	--	1
D-7— 9B	44	30	2	9	7	4	20	--	--	0.5
D-7—10A	49	15	8	--	-	-	.	--	--	--
D-7—12A	59	18	5	5	12	12	65	10	5	--
D-7—13A	64	28	3	12	9	17	80	8	--	-
D-7—15A	79	10	2	7	12	18	70	10	--	--
D-7—16A	90	13	2	9	10	17	60	5	--	--
D-7—18A	109	30	4	15	9	7	40	2	--	--

* Equivalent weight percent of reference minerals.

spacings. After firing at 600° C the 14 Å reflection intensity was greatly increased but the others were no longer present. Some chlorites have a 12Å spacing after firing. The 14 and 12 Å lines of samples fired at 600° C were adopted as indices for estimating the amount of chlorite present.

Feldspar. X-ray diffraction and D.T.A. tests indicate that the DAMF sample contains about 40 percent quartz. No minerals other than feldspar were detected in appreciable amounts. The characteristic lattice spacing used for feldspar is 3.20 Å. This spacing varies slightly with changes in feldspar composition. Glycolation and heat treatment have no effect on it. The base-exchange capacity was found to be 5.2 meq per 100 gms. D.T.A. studies, as expected, showed that feldspar has no characteristic exothermic or endothermic peaks. The feldspar portion of the DAMF sample was adopted as a reference mineral.

Illite. In this study the Grundite sample was the reference mineral for illite, which is here used as a group name to include the micaceous-like clay minerals. X-ray diffraction and D.T.A. tests indicated the presence of about 22 percent quartz, some organic matter, and possibly a small amount of montmorillonite. On this basis the illite content was estimated to be about 75 percent. The X-ray diffraction lines used for quantitative analysis had d-values of 10 and 4.46 Å. These spacings did not shift with glycolation or heat treatment. The sharpness and intensity of the peaks, however, were much more prominent in the fired samples. The oriented and glycolated samples showed only a faint indication of a regular spacing at 10 Å, but the samples heated to 450 or 600° C. developed a rather sharp peak. The intensity of the 4.46 Å line was increased about threefold by heating to 600° C. The identification and quantitative estimation of illite-type materials is frequently complicated by the presence of other minerals also having a 10 Å spacing and by their overall weak reflections. The analyses of the samples for illite were based primarily on the variations of the 4.46 Å line, but the 10 Å line plus any other distinguishing factors that were available were also considered.

Differential thermal analysis was not useful in identifying illite when illite was a minor component in the sample. Also, because of the relatively small and variable thermal effects, it was not feasible to attempt quantitative analyses by this method even for samples containing larger quantities of illite. The principal value of D.T.A. was as supplementary evidence. The base exchange capacity of the Grundite sample was 18 meq per 100 gms.

Montmorillonite. X-ray diffraction and D.T.A. studies of the Wyoming Bentonite sample indicated the presence of about 4 percent quartz. Because no other minerals were detected, the remainder was assumed to be montmorillonite. The effect of glycolation and heat treatment on the three X-ray diffraction lines used in the identification of the expansion-type montmorillonite lattice is indicated in table 7. The expanded glycolated 17 Å spacing was used to estimate the amount of montmorillonite.

D.T.A. techniques were not adequate for identifying montmorillonite as a minor constituent in a complex mixture of clays, although the results are much more dependable than those for illite. Good quantitative

Table 7. Observed montmorillonite spacings.

Oriented	Glycolated	Fired, 450° C.	Fired, 600° C.
12.6 Å	17 Å	9.7 Å	9.6 Å
6.3 Å	8.6 Å	4.82 Å	4.79 Å
3.34 Å	3.40 Å	3.18 Å	3.18 Å

data also are difficult to obtain by these methods. The base exchange capacity of the montmorillonite sample was 78 meq per 100 gms.

Kaolinite. Four samples of kaolinitic material were examined. X-ray diffraction and D.T.A. runs showed that two of these, DRG and ASP-900, had no detectable minerals other than kaolinite. The other two, Kentucky Mine Special and Kentucky Old Mine No. 4, were found to contain impurities such as organic material, quartz, and other clay-lattice mineral types.

On the basis of the reference minerals already mentioned, the Kentucky Mine Special sample was estimated to have 20 percent quartz, 10 percent illite, and an undetermined amount of organic material. Some of the illitic portion is believed to be similar to hydrous mica because some hydration occurred but no expansion of the lattice resulted on exposure to ethylene glycol vapors. Its base-exchange capacity was found to be 12.9 meq per 100 gms.

The Kentucky Old Mine No. 4 sample was similar but contained a higher percentage of kaolinite. The impurities were estimated to be 12 percent quartz and 6 percent illite, as well as some organic matter. The base-exchange capacity was 10.0 meq per 100 gms. The base-exchange capacity of DRG and ASP-900 materials were 2.3 and 3.9 meq per 100 gms respectively.

The characteristic X-ray reflections for kaolinite have d-values of 7.2, 4.45, and 3.58 Å. These reflections are not affected by glycolation or heat treatment at 450° C. but disappear after heating to 600° C. The DRG sample was adopted as the kaolinite reference mineral for this work. Although D.T.A. thermographs were quite distinctive for kaolinites, the technique was not satisfactory for recognizing small amounts of kaolinite in the presence of other clay minerals.

Reference Mixtures and Unknowns. The results obtained from the second group, made up of the prepared reference mixtures, have al-

Table 8. Quantitative estimates of quartz.

Sample	Percent quartz	Intensity, c/s, 3.35 Å line oriented sample	Differential thermal analysis area, cm^2, 573° C. peak
Silica No. 2	100	1,320	1.60
Reference mixture A	47	670	0.55
Reference mixture B	53	655	0.65
Reference mixture C	35	495	0.20
Reference mixture D	13	288	--
Reference mixture E	18	385	--

ready been presented in figures 4 and 5. The former figure shows tracings of the D.T.A. curves. The latter figure pictures the change in intensity of selected X-ray diffraction peaks versus changes in concentration.

The mineral compositions of the third group of samples as determined from comparison with the reference minerals and mixtures are presented in tables 4, 5 and 6.

Methods of Estimating Clay-Mineral Content

X-ray Diffraction. In preparation of materials for X-ray diffraction analysis, some workers first make a dispersion, allow it to settle, and decant the suspended minus two micron fraction for examination. Other investigators work with the entire sample. The deciding factor between these approaches is whether or not the worker believes segregation occurs during the settling process, which is used to orient the specimen for X-ray studies because of the platy morphology of clay minerals. The occurrence of segregation would require the study of a number of size fractions separately. Under any circumstances the stacking of the flat clay platelets produced by settling emphasizes the basal reflections. Such emphasis permits the identification of small amounts of certain clay minerals that otherwise might not be apparent.

Factors, such as differences in density or particle size, that could produce different settling characteristics and thus segregation, have not been especially considered in this work. However, it is believed that little or no segregation did occur, because the materials had been dry ground to minus 200 mesh and a maximum settling distance of the suspension was kept at one or two cm. When oriented samples, prepared at densities of 10 and 20 mg of material per square inch on the glass slides, were compared, no segregation was noticed as indicated by comparing the observed relative reflective X-ray intensities of characteristic spacings.

The data presented in figure 5 provided a basis on which quantitative estimates of quartz, kaolinite, montmorillonite, and illite could be made with an estimated accuracy of 15-20 percent. After the reference mixtures had been prepared, the analysis of the unknowns of the third group indicated the presence of chlorite and feldspar. The quantitative analysis of chlorite and feldspar in these samples is thus based only on the individual Sierralite and DAMF samples. Consequently, the accuracy of chlorite and feldspar estimates is probably less than that for the other components.

It is to be noted from table 2 that the kaolinite X-ray diffraction reflections are masked by those of chlorite. Although it is thus difficult to identify kaolinite in the presence of chlorite, careful examination of the patterns does show an extra distinguishing shoulder on the 7.2 Å peak after firing to 450° C. This effect is the result of a slightly different degree of heat stability of the two minerals.

Differential Thermal Analysis. Dehydration or loss of crystal structure or both are characteristic endothermic reactions, and the formation of new phases and oxidation are exothermic reactions. These reactions, if present, generally occur at specific temperatures for a given mineral and can be used as a means of identification. Differential thermal analysis (D.T.A.) techniques are based on these characteristics. If the

amount of heat involved is small and the reactions are not sharply defined, indefinite results may be obtained. Peaks shown by organic material, which vaporizes or burns when heated in the presence of air, or a large strong peak produced by another component may mask less prominent reactions. This masking makes it difficult to use D.T.A. for the identification of minor components. Kaolinite and montmorillonite have more prominent characteristics and thus are easier to measure than illite. The alpha-beta quartz inversion point at 573° C is not prominent during heating if clay minerals are present. On cooling, however, the quartz inversion peak is the only reversible reaction and thus can be used as an approximate estimate of the amount of quartz present. D.T.A. and X-ray diffraction data for the identification of quartz are compared in table 8.

In general, except for the estimates of the amount of quartz, D.T.A. data have not been useful for quantitative work on unknown complex mixtures. It is possible to recognize major components, but minor components are not clear. However, if the composition of a series is known, it is possible to follow a progressive change in the shapes of the curves as seen by studying the curves in figure 4 for the reference mixtures listed in table 3. The greatest value of D.T.A. is its use in conjunction with X-ray diffraction.

Base-Exchange Analysis. Although the clay minerals have different base-exchange capacities as shown in table 1, the data on base-exchange were of little assistance in estimating the relative amounts of clay minerals in complex mixtures. At best, only the possible presence of a certain type of clay or mixture of types of clay was suggested by the base-exchange data.

Because of the variations in the clay minerals due to solid solutions, or to interstratification of different layers or both (particularly in those minerals other than kaolinites), it was not possible to have just one sample, no matter how close to ideality it might be, as a standard that could be used for quantitative work. For accurate analysis it would be necessary to separate a sample of each mineral from the sediment being analyzed and to calibrate with them. As this procedure is tedious, it was not followed in this study. Therefore, there is a possibility of error because the reference minerals used were not obtained from the sediments.

EFFECT OF CLAY COMPOSITION ON STRENGTH

Data Obtained

The content of each clay type in the borehole samples is given in tables 4, 5, and 6. These data indicate that clays in the vicinity of San Francisco are predominantly illite. However, all samples contain a subordinate amount—2 to 18 percent—of montmorillonite. Chlorite is present in minor quantities—0.1 to 10 percent. No more than 2 percent of kaolinite is present. The percentages in tables 4, 5, and 6 do not total 100 percent because reference standards were not based on the actual clay minerals in the samples.

Data on strength and other physical characteristics of these samples are given in tables 9, 10 and 11. Estimates of montmorillonite are also included for purposes of comparison. The physical characteristics shown

Table 9. Basic data from borehole samples, San Francisco Bay.[1]

Sample number	Elevation[2] feet	Unit weight (wet) lbs/ft³	Moisture (percent) dry weight	Atterberg limits		Direct shear tons/ft²	Montmorillonite (percent)
				Liquid limit	Plasticity index		
6	—18	104	59	34	12	0.075	5
1	—25	94	79	--	--	--	3
4	—55	129	23	43	22	--	6
7	—68	122	28	56	31	0.85	6
5	—85	110	44	69	35	--	8
2	—88	102	60	88	50	0.70	10
8	—105	116	34	46	26	0.70	6
9	—114	118	33	54	30	1.20	14
3	—118	117	37	56	31	0.85	4
10	—125	113	39	63	36	--	6
11	—144	133	18	32	15	--	4
12	—176	127	25	47	28	--	6

[1] Data and samples supplied by Norman H. Raab, Chief Engineer, California Division of San Francisco Bay Toll Crossings; and F. N. Hveem and A. W. Root, Materials and Testing Laboratory, California Division of Highways, Sacramento, California.
[2] Elevation based on U. S. C. & G. S. 1929 mean sea level datum.

in these tables are: unit weight, moisture, Atterberg limits, direct shear, unconfined compression, and grain-size distribution.

The unit weight is a measure of the density of the wet soils as collected, expressed in pounds per cubic foot. The moisture content is the ratio of the weight of contained water to the weight of dried solids. The Atterberg limits are measures of the plasticity of the sediments. Two limits are given in table 9, the liquid limit and the plasticity index. The liquid limit is the water content of a sediment which defines the boundary between the liquid and plastic states. The plastic limit represents the water content at the boundary between a plastic and nonplastic state. The plasticity index is the difference between the liquid and plastic limits.

Table 10. Basic data from borehole samples, Sonoma County, California.

(From borehole P-1, Route 37 at Sonoma Creek, surface elevation 1 foot.) *

Sample	Depth (feet)	Unit weight (wet) lb/ft³	Moisture (percent dry weight)	Grain size (microns)			Unconfined compression[1] (tons/foot²)	Montmorillonite (percent)
				D25 quartile	D50 quartile	D75 quartile		
1	4	89	90	6.5	15	35	0.29	2
2	9	97	70	4.0	11	28	.25	3
4	17	96	72	2.2	5.7	18	.23	7
5	23	97	75	2.6	5.7	22	.40	3
6	33	99	66	2.3	5.2	18	--	3
7	43	106	51	2.4	8.3	27	.60	4
8	53	105	51	2.3	8.2	24	.69	4
9	68	108	50	1.8	8.2	24	.86	6
10	75	108	43	4.7	12.5	27	.41	6

* Data supplied by F. N. Hveem and A. W. Root, Materials and Testing Laboratory, California Division of Highways, Sacramento, California.
[1] Direct shear is approximately one-half the unconfined compression.

Table 11. Basic data from borehole samples, Monterey County, California.

(From borehole D-7, Elkhorn Slough, 3 miles north of Castroville. Surface elevation, 1 foot.) *

Sample	Depth (feet)	Unit weight (wet) lb/ft³	Moisture (percent dry weight)	Grain size (microns) D25 quartile	D50 quartile	D75 quartile	Unconfined compression (tons/foot²)	Montmorillonite (percent)
1	4	103	58	1.5	5.8	19.5	0.29	--
2	8	--	65	1.1	2.7	8.7	--	9
3	13	92	93	2.4	10.5	29	.30	11
4	19	102	62	--	[1]5	--	.20	10
6	29	95	81	1.4	2.9	8.7	.32	--
8	40	115	33	4.8	125	250?	[2].25	4
9	44	103	55	1.7	4.9	13.5	.29	4
10	49	113	41	--	[1]5	--	.47	--
12	59	115	37	1.5	12.5	90	.28	12
13	64	106	52	1.5	3.2	12.5	.45	17
15	79	98	62	1.6	4.3	12.0	.39	18
16	90	102	50	--	[1]5	--	.52	17
18	109	105	51	--	[1]4	--	.63	7

[1] Estimated from binocular inspection of samples.
[2] Based on cohesion of 250 lbs. per square foot.
* Data supplied by F. N. Hveem and A. W. Root, Materials and Testing Laboratory, California Division of Highways, Sacramento, California.

The direct shear shown in table 9 and the unconfined compressive strength shown in tables 10 and 11 are measures of the strength of unconsolidated materials. In the direct shear test the samples are placed in a shear box, and subjected to the so-called direct-quick shear procedure. In the unconfined compression tests, unsupported cylindrical samples are compressed until they fail. The shear strength is approximately one-half the unconfined compressive strength (Terzaghi and Peck, 1948, p. 185). Both units are measured in tons per square foot of area.

The grain-size distribution is given in terms of the three quantities, D_{25}, D_{50} (the median), and D_{75}. Twenty-five percent of the weight of the samples is composed of particles smaller than diameter D_{25}, 50 percent is smaller than the median or D_{50}, and 75 percent of the weight of the sample is composed of particles smaller than D_{75}. Data on grain size are not available for table 9, but all samples are clayey, having a median diameter estimated to be 3 to 5 microns, as based on microscopic inspection, and by analogy with similar sediments from San Francisco Bay (Trask and Rolston, 1951, p. 1105). The samples from all three boreholes are silty clays or clayey silts.

Effect of Montmorillonite

The montmorillonite content shows a fairly definite relationship to the shear strength of the sediments. In the samples from San Francisco Bay it ranges from 4 to 14 percent, averaging 6.5 percent. Montmorillonite is greatest in sample 9 (14 percent), and sample 2 (10 percent). Sample 9 has the highest shear strength, 1.2 tons per square foot with a water content of 33 percent. Sample 2 has a very high shear strength of 0.7 tons per square foot for its 60 percent water content. Sample 8, which is the next deepest sample, has the same shear strength, 0.7 tons

per square foot, but has only 6 percent montmorillonite and 34 percent water. Thus, samples with higher percentages of montmorillonite have greater strength than others with the same water content, and can contain more water than others and maintain the same shear strength.

The montmorillonite content of samples from Sonoma Creek, table 10, ranges from 2 to 7 percent, averaging 4.2 percent. The samples from this locality, which have a relatively low strength at comparable water content are relatively low in montmorillonite. Sample 9, which contains 6 percent montmorillonite, and was taken from a depth of 68 feet, is an exception as it has an unconfined compressive strength of 0.86 tons per square foot (equivalent to a shear strength of 0.43 tons per square foot). This is not particularly strong for a water content of 50 percent. Also, it is relatively weak when compared with sample 2 from San Francisco Bay, which contains 60 percent water, 10 percent montmorillonite, and has a shear strength of 0.7 ton.

The samples from Elkhorn Slough, 100 miles south of San Francisco Bay, presented in table 11, are weaker for a given water content than those in San Francisco Bay, yet they are higher in montmorillonite which ranges from 4 to 18 percent with an average of 11 percent. Nevertheless, at Elkhorn Slough, also, except for sample 18, the strongest sediments have the highest montmorillonite content. Samples 13, 15, and 16 contain about 17 percent montmorillonite and have an unconfined compressive strength of 0.39 to 0.52 ton per square foot. Sample 18 is an exception as it has an unconfined compressive strength of 0.63 tons per square foot and a low montmorillonite content of 7 percent. Its water content of 50 percent is comparable to samples 13 to 16. It is relatively strong.

Although no analytical data were obtained while working with these samples, it was noticed that most of the samples from the Elkhorn Slough area were of a finer grain size and had a greater tendency to act like hydrous mica than samples from the other areas, which could account for this series of samples being weaker than the other two.

The plasticity index, as shown in the data for the samples from San Francisco Bay (table 9), varies roughly with the montmorillonite content, ranging from a low of 12 percent in sample 6 with 5 percent montmorillonite to 50 percent in sample 2 with 10 percent montmorillonite. Sample 9, with a plasticity index of 30 percent and a montmorillonite content of 14 percent is an exception.

Conclusions

(1) Owing to the pronounced effect of water upon strength, it is desirable to compare the strength of sediments having similar water contents. Such an investigation would require a large suite of samples and should yield curves that would correlate strength with water content for various clay compositions. These basic correlations would make it possible to determine the relative strength of a sample and would allow the effect of component clay minerals to be more accurately studied.

(2) The available data are somewhat conflicting, partly because the suite of samples studied was too small and partly because so many variables are uncontrollable, but it seems that the presence of montmorillonite in moderate amounts makes sediments relatively strong.

This relationship corresponds with the results obtained in studying synthetically produced sediments as well as with the findings of other workers (Trask and Close, 1958). Montmorillonite also tends to increase the plasticity index.

(3) The sediments studied are all relatively high in illite, moderately low in montmorillonite, low in chlorite, and extremely low in kaolinite.

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SAND AND GRAVEL RESOURCES OF CACHE CREEK IN LAKE, COLUSA, AND YOLO COUNTIES, CALIFORNIA †

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OUTLINE OF REPORT

Illustrations

† Manuscript submitted for publication January 1957.
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Illustrations—Continued

Illustrations—Continued

ABSTRACT

The Cache Creek basin drains a portion of the northern Coast Ranges and is part of the Sacramento River drainage system. Rocks underlying the basin are mildly metamorphosed sandstone, shale, chert, and basic igneous rocks of the Franciscan group; sandstone and shale of late Jurassic, Cretaceous, Paleocene, and Eocene formations; and conglomerates of the Cache and Tehama formations of Plio-Pleistocene age. Extensive deposits of sand and gravel are concentrated in the lower part of the basin from Capay to Yolo and near Rumsey and Brooks. In the upper part of the basin such materials are concentrated along the North Fork of Cache Creek in Indian Valley and between Chalk Mountain and Wilson Valley. The sand and gravel deposits in both parts of the basin are in large part derived from the reworking of the weakly consolidated conglomeratic Cache and Tehama formations, which in turn were derived by the breakdown of the older units.

The following quantities of sand and gravel suitable for concrete aggregate are estimated from field examination, petrographic studies, and laboratory tests of surface deposits to be available along the lower reaches of Cache Creek: 3,000,000 cubic yards at Rumsey, 5,000,000 cubic yards at Brooks; and 1,000,000 cubic yards per mile between Esparto and Yolo. Commercial production thus far has centered in Yolo and Madison where sand and gravel valued at $806,218 was produced in 1955. Approximately 625,000 tons of sand and gravel was used in the construction of Monticello Dam.

In the upper part of the Cache Creek basin field reconnaissance supported by petrographic and other tests indicates that a few million cubic yards of sand and gravel of marginal to fair quality for concrete aggregate are contained in the stream bed of Cache Creek between the upper end of Wilson Valley and the junction of North Fork Cache Creek, and in North Fork Cache Creek up to the vicinity of the mouth of Long Valley Creek. About the same amount of marginal and submarginal material is available in Indian Valley on the North Fork of Cache Creek.

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INTRODUCTION

In 1954, the California Division of Mines initiated a mineral inventory of the sand and gravel resources in the state in cooperation with federal and state agencies who have made detailed engineering geological investigations of construction materials for use in public work projects.

One such investigation, which was made by the U. S. Bureau of Reclamation, Region II, was for sources of concrete aggregate along Cache Creek. This stream drains a portion of the northern Coast Ranges in Lake, Colusa, and Yolo Counties, about 100 miles north of the San Francisco Bay area, and is part of the Sacramento River drainage area.

The alluvial sources of concrete aggregate were investigated by Mr. Klein, geologist with the U. S. Bureau of Reclamation, Sacramento, California, who made geologic and petrographic studies of the gravel deposits on a reconnaissance in 1947 in the upper part of the Cache Creek basin and, in 1949, in more detail, on the deposits along the lower reaches of Cache Creek in connection with the planning of the Solano project, which includes as its major feature Monticello Dam on Putah Creek. Many of the data used in this report were adapted from his memoranda and records prepared for project-planning studies of the U. S. Bureau of Reclamation who have kindly made the material available for publication. Mr. Goldman, geologist with the Division of Mines, compiled these data, collected additional information, prepared the geologic map and the text, and assisted in preparing the plates.

The purpose of this report is to present a general picture of the sand and gravel resources in the entire drainage basin of Cache Creek and their present state of development; and to call attention to those areas which might be of economic significance for future development. As a guide to future exploration, attention has been directed to existing stream bars and the broad factors that influence these bars as sources of aggregates. The deposits have been classified by the authors in a preliminary fashion as to suitability for use as concrete aggregate. However, in considering them with respect to other specific job requirements, the materials may be evaluated by the reader for other less exacting purposes for which they may meet specifications, such as bituminous aggregate or base course for roads. The comments and the remarks on the suitability of the various undeveloped deposits are the personal non-official opinions of the writers and do not represent the official position of the government agencies with which they are associated.

GEOGRAPHY AND TOPOGRAPHY

The Cache Creek drainage basin, an hourglass-shaped area about 50 miles long and 5 to 16 miles wide, is a part of the Sacramento River drainage system. The principal tributary is the North Fork, which drains an area of 225 square miles; the only other important tributary is Bear Creek. The 610-square-mile area drained by Cache Creek below Clear Lake is outlined on the location map of the Cache Creek basin.

The upper portion of the basin, herein called Upper Basin, lies to the north and east of Clear Lake and is characterized by northwest-

trending ridges with rugged steep-sloped peaks up to 5000 feet in elevation separated by only a few long narrow valley areas. The mountainous areas are covered by dense growths of brush with some pine and oak trees. The Upper Basin is about 25 miles long and 6 to 12 miles wide. The lower portion of the basin, herein called Lower Basin, lies to the south of the town of Rumsey in Yolo County and is characterized by the alluvium-filled trough of Capay Valley, which is bordered on the west by the northwest-trending Vaca Mountains and on the east by the Rumsey Hills and the gently sloping alluvial plain of the Sacramento Valley. Lower Basin is about 25 miles long and 5 to 16 miles wide.

DESCRIPTIVE GEOLOGY

Cache Creek drains a portion of the northern Coast Ranges geomorphic province. The highland areas of the upper basin are composed of sandstone, conglomerate, shale, and chert belonging to the Franciscan group of Upper Jurassic age, as shown on the accompanying generalized geologic map of the Cache Creek drainage basin. These sediments are of marine origin and have been thoroughly consolidated and intensely folded and faulted. In places, dikes and sill-like bodies of ultrabasic rocks, which have been extensively serpentinized, have been intruded into the sediments. The Franciscan group is unconformably overlain by sandstone and shale of Cretaceous age that generally strike northwest and dip at high angles to the northeast. The beds are of marine origin and have been folded and faulted but unlike the Franciscan they are unmetamorphosed. Interbedded in this series is a thick section of detrital serpentine. In Capay Valley a few hundred feet of marine sandstone and shale of Eocene age unconformably overlie the Cretaceous. Along the eastern margin of the range bordering the Sacramento Valley, the Mesozoic and Tertiary rocks are overlain by clay, sand, gravel, and tuff of the contentinental Tehama formation of Plio-Pleistocene age. These sediments have been moderately folded and in some areas faulted. In the vicinity of Clear Lake, the Cache formation and the older rocks are overlain by Quaternary volcanic flow rocks and associated tuffs.

Along Cache Creek and some of the larger tributaries are local deposits of terrace gravels at several levels.

GEOMORPHOLOGY OF THE ALLUVIATED PORTIONS OF THE BASIN

The most extensive deposits of sand and gravel are concentrated in the Lower Basin along the main stream in the Sacramento Valley from Capay to Yolo and in Capay Valley near Rumsey and Brooks; in the Upper Basin in Indian Valley; along the North Fork between Chalk Mountain and the confluence with the main stream; and along the main stream below this confluence as far as Wilson Valley.

Lower Basin Deposits. Cache Creek flows through Capay Valley a distance of 28 miles with an average grade of 9.5 feet to the mile. During this interval the stream is at grade, transporting sand and gravel in the bed load. Large gravel bars have formed near Rumsey and Brooks where the stream profile changes to a gentler slope. The bars range from 0.1 to 0.2 of a mile in width and the gravels range

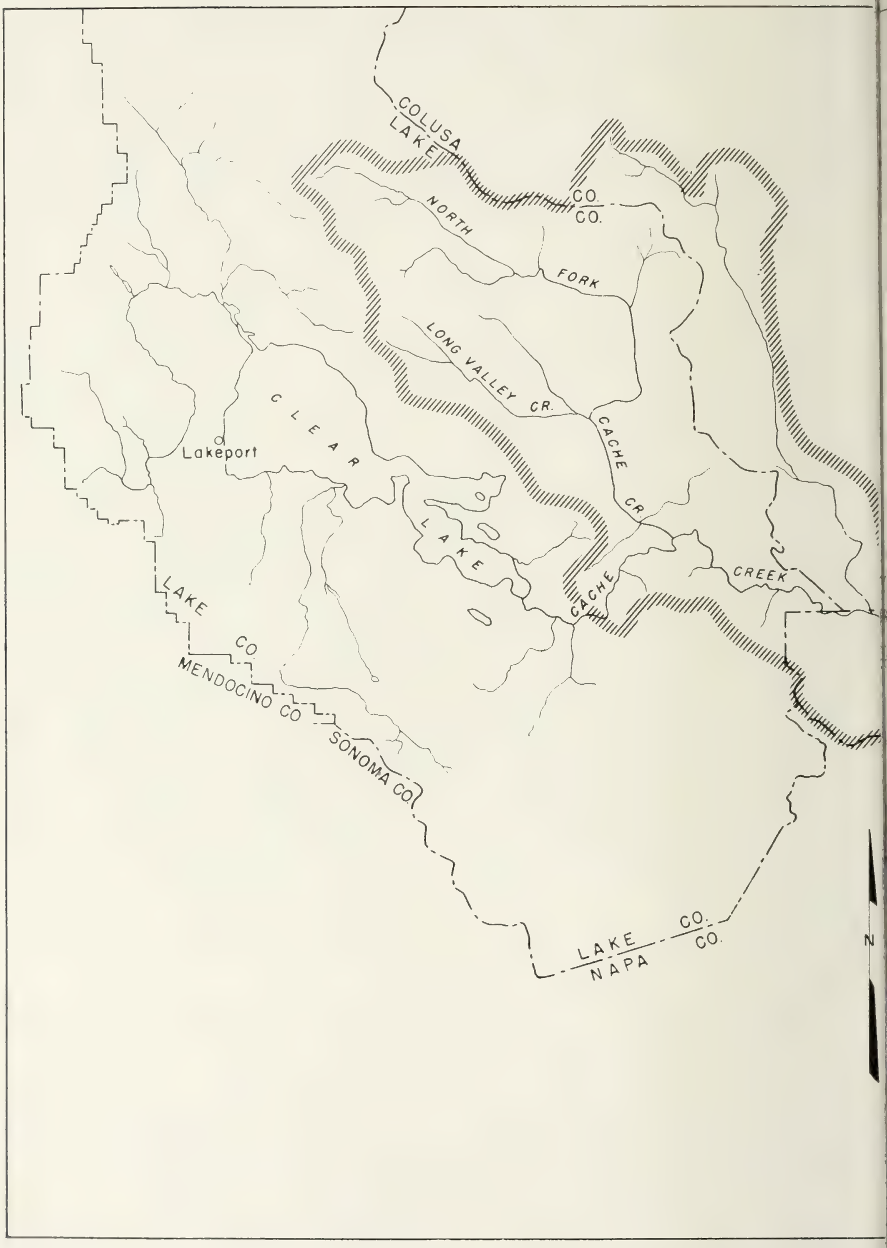
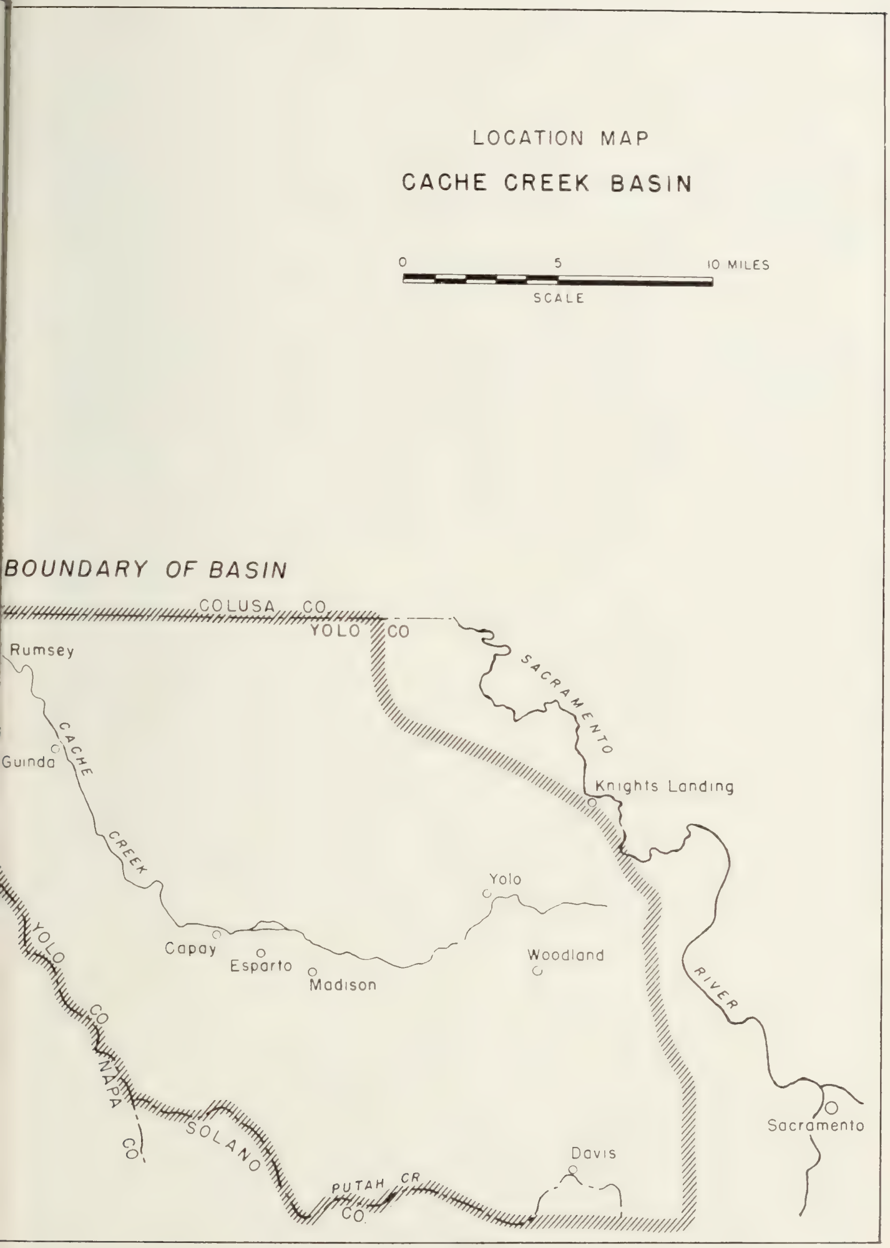


FIGURE 1. Map showing location of Ca



k basin, Colusa, Lake, and Yolo Counties.

from 20 to 30 feet in depth. Part of the gravel, derived from unmetamorphosed Mesozoic sediments above Rumsey, consists of tabular sandstone fragments up to 8 inches in length that gradually diminish in size to a 3-inch maximum downstream at Brooks. Much of the sand and gravel is derived from the weakly consolidated, conglomeratic Tehama formation which comprises the valley floor, and the Pleistocene terraces which border the river plain. The character of the deposits changes as the bed load moves downstream, as increasing amounts of material are added from the Tehama formation and other older alluvial deposits, and the relative proportion of unmetamorphosed sandstones is decreased. At the southern end of Capay Valley, Cache Creek cuts across the trend of the stratified rocks through a narrow gorge, and

FIGURE 2. Monticello Dam, built by U. S. Bureau of Reclamation with aggregate from Cache Creek. The structure, located on Putah Creek near Winters, was completed in 1957. *Photo by E. S. Ensor, courtesy U. S. Bureau of Reclamation.*

sand and gravel are thus transported into the Sacramento Valley. From this point, 3 miles above Capay, a new increment of gravel is derived from the Tehama formation and sand and gravel are deposited in a broad floodplain from Capay to Yolo. The deposit ranges from 0.1 to 0.5 of a mile in width and gravel extends to depths exceeding 50 feet. All the bars are shown on the accompanying map depicting the aggregate resources of the lower reaches of Cache Creek from Rumsey to Yolo. There is a progressive decrease in size from the 6-inch maximum at Esparto to the 1½ inch maximum at Yolo. Cache Creek flows with a grade of 4 to 6 feet per mile in the Sacramento Valley.

FIGURE 3. Landslide in Tehama formation; gravel bar in foreground. On Cache Creek near Guinda.

FIGURE 4. Close-up of an outcrop of the Tehama formation.

Upper Basin Deposits. North Fork Cache Creek rises at elevations up to 5,000 feet and flows southeast in a steep narrow gorge, transporting a relatively small amount of coarse gravel. Between Hough Springs and Indian Valley there are several small, shallow gravel bars approximately 1,000 feet long and 500 feet wide. These are indicated on the accompanying map showing the aggregate resources of North Fork Cache Creek and Cache Creek above Wilson Valley. Stanton Creek, the main tributary to North Fork, also transports relatively small amounts of gravel into Indian Valley. However, in Indian Valley along these two streams there are large deposits of sand and gravel ranging in width from 0.1 to 0.2 of a mile and extending more than 10 feet in depth. Indian Valley appears to be a structural trough in which gravel is deposited during times of high water. Unlike the gravel in the bars below, this gravel is derived exclusively from Franciscan group rocks and is subangular to subrounded in the first cycle of transport.

Leaving Indian Valley, the North Fork of Cache Creek flows west through a steep-walled canyon and then abruptly turns south at Chalk Mountain where it begins to cross the weakly cemented conglomerates of the Cache formation. Sand and gravel is distributed along the stream from Chalk Mountain to its junction with the main branch, a distance of about 7 miles, and along the main branch for several miles below the confluence. This deposit ranges from 0.1 to 0.2 of a mile in width and extends downward for an average depth of 20 feet. The bulk of the sand and gravel is derived from the reworking of the Cache formation which crops out in the banks of the stream. The conglomerates of the Cache formation are composed of gravel similar in lithology to the gravel in Indian Valley. Cache Creek stream bed is alluviated from the junction with the North Fork to Wilson Valley, a distance of about 2 miles. Below Wilson Valley, Cache Creek flows through a deep canyon for 25 miles, along which there are only a few, unimportant small bars. For the first 9 miles the average grade is 40.3 feet to the mile. For the remaining distance the average slope is about 30 feet to the mile to the point where the stream enters Capay Valley.

AGGREGATE-MAKING PROPERTIES OF SOURCE ROCKS IN THE CACHE CREEK BASIN

The nature of the sediments in a stream is determined in a large part by the nature of the source rocks within its drainage area. Although the geology of the Cache Creek basin has not been completely mapped it is fairly well known and is presented in a generalized form in the accompanying geologic map.

Franciscan Group (Map Symbol KJf). The Franciscan group consists principally of mildly to moderately metamorphosed graywacke, chalcedonic radiolarian chert, slaty shale, metamorphosed basic igneous rock (greenstone), and quartz veinlets. Franciscan-group rocks are found only in the Upper Basin to the north and east of Clear Lake.

The graywacke contributes subangular to subrounded pebbles that generally are physically sound. However, badly fractured and deeply weathered graywacke pebbles that constitute a physically unsound ingredient are also contributed. Chert makes very hard, dense, sound peb-

FIGURE 5. Outcrop of Cache formation on state Highway 20, showing how easily the unit is eroded.

FIGURE 6. Close-up of figure 5—the Cache formation, a major source of the Cache Creek deposits. Gravels derived by the reworking of this weakly cemented conglomerate are satisfactory in physical and chemical soundness.

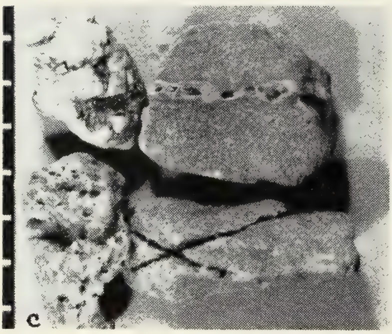


FIGURE 7. Typical stream pebbles in $\frac{3}{4}$- to $1\frac{1}{2}$-inch size range, derived from Franciscan rocks. *A*, Chert. Hard, dense, with smooth glossy surface. Veined with quartz. Blocky form indicates strong resistance to stream abrasion. *B*, Metasandstone. Rough, friable surface from weathering and stream abrasion. Less resistant to abrasion than the chert, and is therefore more rounded. *C*, Vein quartz and metasandstone. Unsound pebbles, badly fractured, deeply weathered, weak, and porous. White veins and patches are quartz. Natural leaching (probably of calcite) leaves vugs and voids, and weakens the rock. *Photos by H. Duane Woods.*

bles. This rock type has been considered potentially troublesome because of alkali-reactivity and is discussed at length under ''chemical quality'' below. Slaty shale is an important constituent of the gravel in the Upper Basin. The very flat character of pebbles of this rock is noteworthy as it constitutes a physical feature not desirable in a concrete aggregate. The metabasic igneous rock generally makes very tough, sound pebbles, but weathered and fractured types, of inferior quality, are common. Badly fractured weak pebbles are derived from the quartz veinlets in the metasediments. On the whole, however, aggregate derived from this unit is fair to satisfactory for use in concrete.

Serpentine (Map Symbol KJsp). Serpentinized ultrabasic igneous rocks are intrusive into the Franciscan group, and also are interbedded as a detrital unit in the Cretaceous section. Serpentine crops out solely within the Upper Basin, to the east of Clear Lake, and in a large mass extending from Wilbur Springs to Indian Valley. The serpentine is differentiated as a separate lithologic unit because pebbles derived from it are on the whole an inferior ingredient. Serpentine is a plentiful constituent of the gravels in the north end of Indian Valley, and in Rocky Creek in Wilson Valley. The large mass of serpentine, drained by Bear Creek, as shown on the geologic map, contributes little detritus to the main stream. Silica-carbonate rocks which are associated with the serpentine constitute a potential source of chemically reactive ingredients because of their high opal content. (See section on quality of materials.)

Undifferentiated Jurassic and Cretaceous Marine Sedimentary Rocks (Map Symbol JK). The undifferentiated Jurassic and Cretaceous sedimentary rocks consist of a wide zone of unmetamorphosed graywacke, shale, and minor conglomerate on the west side of Capay Valley, that extends to the northwest into the lower portion of the Upper Basin between North Fork Cache Creek and Capay Valley. The massive graywacke is typically well-indurated, often carbonate-cemented, and makes good, moderately hard pebbles. However, the softer uncemented deeply weathered or shaley types are often physically unsound. The shale and siltstone contribute very little to the coarse fraction. Minor amounts of dense, hard, sound pebbles are derived from limy layers and concretions in the shale. The Cretaceous conglomerate contributes distinctive, very hard, well rounded, sound pebbles of crystalline metamorphic and igneous rock.

Undifferentiated Eocene and Paleocene Marine Sedimentary Rocks (Map Symbol T). A thin band of Eocene sandstone and shale is found along the western margin of Capay Valley. Paleocene sandstone and shale crop out in a small area to the east of Clear Lake. This unit is not significant as a source of aggregate because little or no gravelly detritus is contributed to the deposits; the sandstone readily crumbles to sand.

Tertiary or Recent Volcanic Rocks (Map Symbol Tva or Tvb). Tertiary or Recent unmetamorphosed basalt, andesite, and rhyolite volcanic rocks abound in the vicinity of Clear Lake. However, the Cache Creek basin only skirts this volcanic area and its contribution to the deposits is practically negligible. The only unmetamorphosed volcanic materials noted in the Cache Creek gravel are extremely sparse basaltic pebbles.

Tehama and Cache Formations (Map Symbol TQc), Quaternary Terraces (Map Symbol Qal). The Tehama formation crops out on both sides of Capay Valley and along the western foothills in the Sacramento Valley. The Cache formation crops out to the northeast of Clear Lake. Quaternary terraces are present along Cache Creek and its larger tributaries, particularly in Capay Valley. These lithologic units are characteristically composed of weakly cemented conglomerate derived from the older formations previously described. In outcrop the pebbles in these formations usually show some degree of weathering. However, when they are reworked by Cache Creek, the weaker, weathered material is eliminated, leaving only the more resistant and durable. Thus, in the Cache Creek basin, the Tehama and Cache formations constitute a major source of the gravel, which is physically and chemically sound.

LABORATORY TECHNIQUES USED IN EVALUATING SAND AND GRAVEL DEPOSITS

A suitable aggregate has many requirements that are difficult to meet if only unprocessed material from natural deposits is used. Suitable material is composed of clean, uncoated, properly shaped particles which are sound and durable. Soundness and durability denote the ability of an aggregate to retain a uniform physical and chemical state over a long period of time so as not to disrupt concrete exposed to weathering and other destructive processes. To have these attributes, individual particles must be tough and firm, possessing the strength to resist stresses and chemical and physical changes such as swelling,

cracking, softening, and leaching. The aggregate should not be contaminated by much clayey material, silt, mica, organic matter, chemical salt, or surface coating.

In addition to the suitability of the individual particles, the overall assemblage of particles should be such that proper grading in the various sizes can be obtained. The grading of concrete aggregate has very pronounced influence on the workability of the concrete mix and the proportion of cement and water needed to produce high-quality concrete.

The geological and engineering aspects of an investigation of alluvial deposits to evaluate their suitability for aggregate have been covered in numerous articles, some of which are given in the list of references at the end of this paper. For a brief review of the subject the reader is referred to the article *Sand and Gravel for Concrete Aggregate,* by H. B. Goldman, in the January 1956 issue of the California Journal of Mines and Geology.

Laboratory Examination. Laboratory testing is a means of scientifically evaluating the suitability of aggregate material. In an attempt to forecast the behavior of the aggregate in concrete, numerous tests have been devised, many of which are complicated and require expensive equipment and trained technicians. Several of these tests have been used for many years and are familiar to those in concrete construction work. A strong effort is being made to standardize testing procedures throughout the nation and many laboratories use, with little or no modification, test methods as set forth in detail by the American Society for Testing Materials. The principal tests performed on aggregates are for toughness and abrasion resistance, soundness, organic content, grading, specific gravity, absorption, and alkali-aggregate reactivity. Petrographic examination supplements the laboratory tests.

Petrographic Examination. Petrographic examination is the visual appraisal of suitability based on the detailed scrutiny of samples by a geologist specially qualified in concrete technology and in laboratory analysis and classification of rocks. Standardization of methods of making such studies is a relatively recent development. The scheme followed in the study of the Cache Creek material was developed by Mr. Klein during the period 1947-48 during the appraisal of gravel deposits in central and northern California in connection with water-development projects of the federal government.

The laboratory procedures and various quality categories followed in this scheme, as described later in this paper, and used in tables 1 and 2, are a modification and in certain respects an expansion of the U. S. Bureau of Reclamation procedures as described by Mielenz (1946, 1954), and Rhoades and Mielenz (1946). In 1954, the American Society for Testing Materials adopted a standard method for petrographic examination of aggregates for concrete, ASTM Designation C295-54, that is highly recommended for general usage.

As a result of this work it is felt that a competent petrographer can readily establish the relative merit of alluvial materials as concrete aggregate, and can reasonably well predict, except for very marginal conditions, whether or not the material will pass or fail the various standard acceptance tests. However, petrographic examination is not

recommended as a substitute for, but rather as a very valuable supplement to laboratory tests. Closely coordinated geologic field work and petrographic laboratory testing can cut down on expensive time-consuming sampling and laboratory programs.

Standard Laboratory Acceptance Tests

Toughness and resistance to abrasion are determined by abrasion tests, such as the Los Angeles Rattler and wet shot tests.

Los Angeles Rattler Method. The Los Angeles Rattler method is used to determine the resistance of mineral aggregate to combined impact and abrasion in a rotating cylinder containing metallic spheres. The procedure consists of placing a graded and weighed sample in a metal cylinder 28 inches in diameter and 20 inches in height with 6 to 12 iron or steel spheres approximately $1\frac{7}{8}$ inches in diameter, each weighing about 1 pound. The machine is rotated about a horizontal axis at a speed of 30 to 33 rpm for 100, 500, or 1,000 revolutions, after which the sample is removed, resieved, and reweighed. The difference between the original and the final weight of the test sample is expressed as a percentage of the original weight and reported as the percentage of wear.

Wet Shot Method. The wet shot test is conducted in a manner similar to the Los Angeles Rattler test except that water is present in the cylinder.

FIGURE 8. Los Angeles Abrasion Machine (Los Angeles Rattler). Toughness and resistance to abrasion are determined with this machine. The gravel is placed in the cylinder with metal balls, and revolved. *Photo by Mary Hill.*

FIGURE 9. Coarse grading machine used to determine particle-size distribution of coarse aggregate. The sample is mechanically separated into decreasing sizes. *Photo by Mary Hill.*

Sodium Sulfate or Magnesium Sulfate Soundness Test. The soundness of aggregate is determined by a quick test method which measures the resistance of the aggregate to disintegration by the force of crystallization of salts absorbed from a saturated solution of sodium or magnesium sulfate. The procedure involves sieving and weighing the samples, immersing desired size gradings in prepared hot solutions of these salts for 16 to 18 hours, removing and drying and then repeating the entire cycle. After the final cycle, the samples are washed, dried, resieved, and reweighed. The weighted average percent loss is then calculated from the percentage of loss for each fraction. The fraction larger than ¾-inch is examined visually to detect any disintegration, splitting, crumbling, cracking, flaking, etc., caused by crystal growth in the fractures, pores, and capillaries.

Freeze-Thaw Test. The freeze-thaw method consists of mixing the aggregate sample with a standard mixture of cement, entrained air, and water to form test beams. These beams are cured and then subjected to cycles of freezing at 0° C and thawing to 40° C. The change in the dynamic modulus of elasticity is measured periodically by sonic equipment (electronically). Durability is judged by the percent change in the modulus of elasticity with continued cycles of freeze-thaw. This method has the disadvantage of being much slower than the sodium sulfate (or magnesium sulfate) test.

Organic Content Test. The organic impurity in the finer fractions of the aggregate sample is determined by a color test using a 3 percent

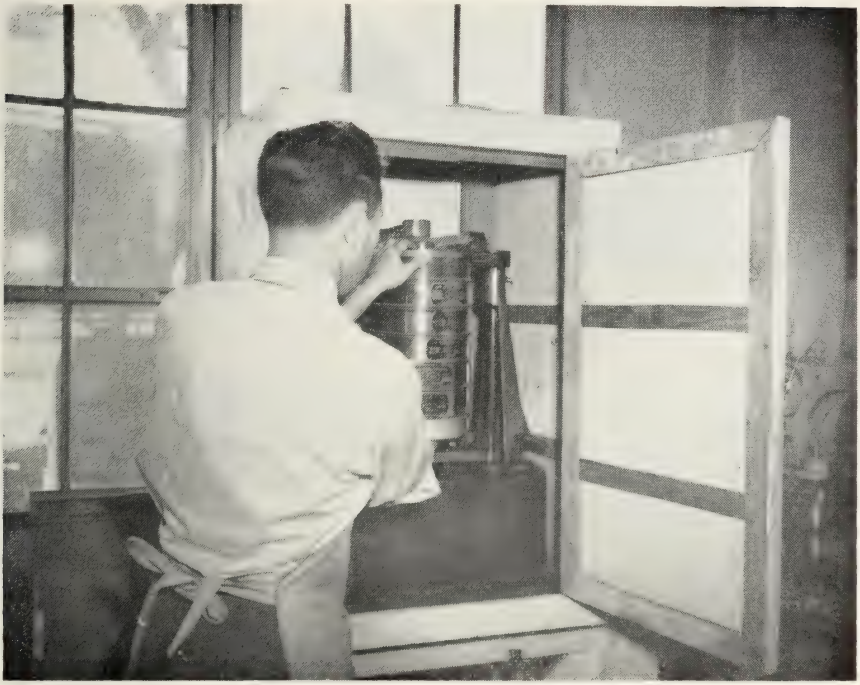


FIGURE 10. Sieve shaker used to determine particle-size distribution of fine aggregate. The machine shakes the sand through sieves of decreasing size openings. *Photo by Mary Hill.*

sodium hydroxide solution. A specified amount of the sample is placed in a container with the solution, agitated, and allowed to stand 24 hours. The color of the liquid is then determined by electric colorimeter using a standard color-comparison solution of tannic acid, alcohol, and sodium hydroxide.

Size and Grading. The determination of the particle size distribution of aggregates is a standard laboratory procedure which involves the use of sieves. The sample is weighed and run through nested sieves of progressively finer mesh openings, vibrated either mechanically or by hand. The size fraction that accumulates on each sieve is then weighed and the results are reported variously as total percentages passing each sieve, as total percentages retained on each sieve, or as an artificial number called the "fineness modulus". The fineness modulus is obtained by adding the cumulative percentages retained on the #100, 50, 30, 16, 8, 4, $\frac{3}{8}$-inch, $1\frac{1}{2}$-inch, and 3-inch sieves, and dividing by 100.

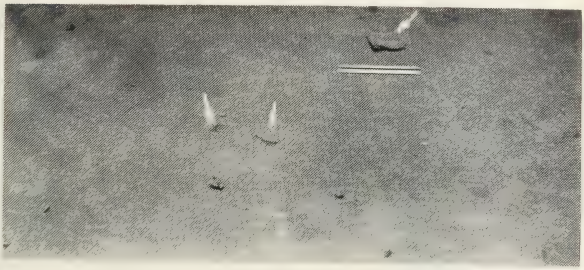
Specific Gravity and Absorption. Specific gravity and absorption are utilized as a basis for designing concrete mixtures and are also important in determining the quality of the aggregate. The test procedure consists of weighing the water-saturated sample both in air and in water, and again after it has been oven-dried. Absorption and specific gravity are then calculated, using the results of the weighings. Specific gravity is expressed by the ratio of the weight of a given volume of aggregate to the weight of an equal volume of water. Absorp-

tion is expressed as a percent ratio of the weight of moisture absorbed to the dry weight of the material.

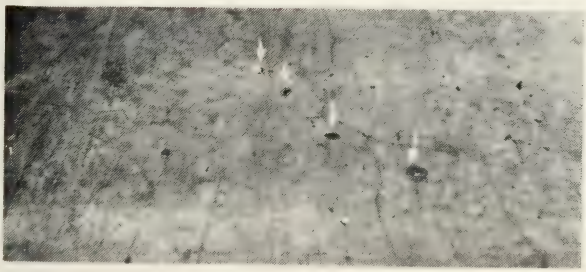
Sand Equivalent. The California Division of Highways has recently adopted a test to determine the effective volume of detrimental fine dust or clay-like materials in fine aggregates (California Standard Specifications, 1954, p. 26). The test is performed by shaking (using a prescribed technique), a known volume of the sample in a glass cylinder with a water solution of calcium chloride, glycerine, and formaldehyde. The mixture is permitted to stand 20 minutes and the relative volume of the clay and sand is then measured. The sand equivalent is the ratio of the volume of sand to the volume of clay and is expressed as a whole number. The higher the number the lower the clay content.

FIGURE 11. California Division of Highways sand equivalent test. This test provides a rapid determination of the ratio of the sand to clay-like material in the fine aggregate. *Photo by Mary Hill.*

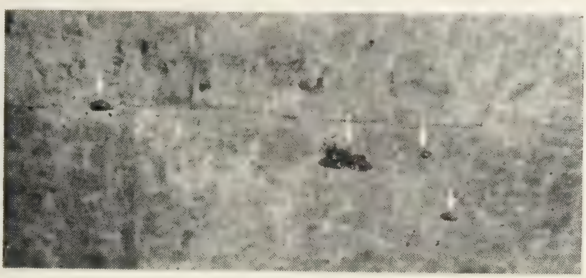
Alkali Reactivity Tests. Alkali-aggregate reactivity has beeen discussed at length in many publications (Merriam, R., 1953). A reactive aggregate is any rock, gravel, or sand that contains one or more constituents that react chemically with the alkalies (sodium and potassium) in some types of portland cement. This reaction, which may result in expansion, cracking, and deterioration of concrete, arises from osmotic pressures produced by the formation and hydration of alkali silica gels. The gels are formed through interaction between the mineral aggregate and the alkalies which are liberated by the cement during hydration (McConnell et al., 1950, p. 234). Opal (amorphous hydrous silica)



A. Pop - outs in place - Scale is 6 inches.



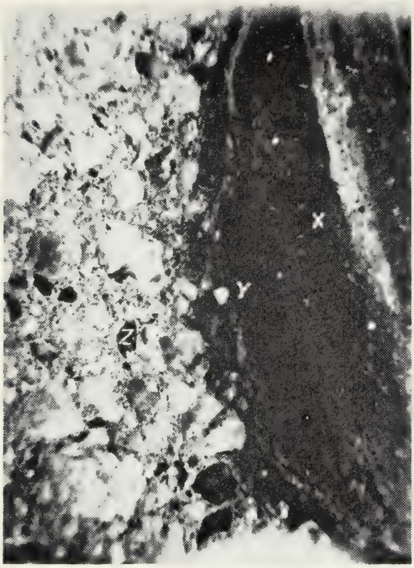
B. Pop - outs removed. Note white pebble in center of cavity and pattern cracking.



C. Pop -outs and pattern cracking.

D. Pop - outs and pattern cracking.

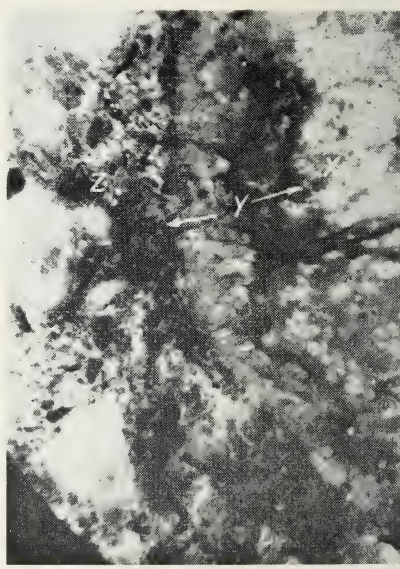
FIGURE 12. Effects of alkali reactivity in concrete. Pop-outs resulting from reaction between an opaline shale pebble and the alkalies in the cement. *Photo courtesy Corps of Engineers, U. S. Army.*



A. Magnification 10 X.

B. Area lined-in in Figure A.
Magnification 30 X.

C. Magnification 10 X.



D. Area lined-in, Fig. C.
Magnified 30 X

FIGURE 13. Photomicrographs of pop-outs in concrete (shown in figure 12). Unaltered opaline shale pebble (X), silica gel (Y), and concrete mortar (Z), under reflected light. *Photo courtesy Corps of Engineers, U. S. Army.*

is the most conspicuous aggregate material reacting in this manner. Other rocks and minerals known to be reactive are: glassy volcanic rocks, chalcedonic rocks, certain phyllites which contain a hydro-mica, and the minerals tridymite and heulandite. Any rock containing a significant proportion of reactive substances may be deleteriously reactive; thus normally non-reactive sandstone, shale, basalt, granite, and other rock types may be harmful if impregnated or coated with opal, chalcedony, or other reactive substances.

There are several approaches to the determination of harmful quantities of chemically reactive impurities in aggregates. Petrographic examination for physical and chemical properties has been mentioned previously. During such examinations the petrographer is alert for the presence of constituents that may be chemically unsound. By using the petrographic microscope one can readily identify reactive ingredients such as opaline silica, chalcedony, and volcanic glass, and estimate the quantity present. On the basis of petrographic observations, aggregates containing suspected reactive materials can be subjected to such substantiating laboratory tests as the mortar bar expansion test and the chemical method of determining potential reactivity.

In the mortar bar expansion test the test aggregate is sieved and mixed with cements of known alkali content to form 1-inch x 1-inch x 10-inch mortar bars. These are cured under laboratory conditions of controlled temperature and heat for specified lengths of time, usually 1 to 2 years. Periodically the lengths of the bars are measured and the reactivity expressed as the percentage of expansion in a given length of time. The excessive length of time required to perform this test has led to the establishment of a quick chemical test.

The chemical test for determining potential reactivity of aggregates is based on the degree of reaction of the aggregate with a sodium hydroxide solution under controlled laboratory test conditions. The procedure as described by Mielenz (McConnell et al., 1950) involves digesting a pulverized sample of the material in a sodium hydroxide solution and filtering the mixture. A portion of the filtrate is analyzed to determine the amount of dissolved silica. The alkalinity of the balance of the filtrate is determined chemically by comparison with a solution of known acidity. The amount of dissolved silica and the reduction in alkalinity is used as a measure of the potential reactivity.

General Specifications for Concrete Aggregate

The study of the results of laboratory tests of aggregates that have good service records in concrete has led to the establishment of certain minimum requirements or specifications to which aggregates are expected to conform. These specifications are designed so that completely serviceable concrete would be made, using any aggregate that meets the requirements. Most specifications are written by government agencies, engineering societies, and concrete technologists with an attempt to conform to standard specifications set up by the American Society for Testing Materials, but modifications of the standard for certain types of concrete work make it difficult to compare individual requirements of these organizations. Therefore to evaluate the suitability of a deposit by judging the test results of selected samples is a difficult task. Some deposits which may not meet certain required specifications

may have to be utilized because of other outside factors, such as the greater expense of hauling a more suitable aggregate.

In general, aggregate from an untried deposit will be satisfactory for most uses if it meets the following minimum standards (these specifications are a general average of the basic requirements recommended by the American Society for Testing Materials, California Division of Highways, U. S. Army Corps of Engineers, and the U. S. Bureau of Reclamation).

Abrasion—The abrasion loss should be less than 30 percent.

Soundness—The loss in the sodium sulfate test should be less than 10 percent.

Specific Gravity—The specific gravity should be greater than 2.55.

Size and Grading—
  a. The deposit should have proper grading so that the fine aggregate will contain no more than 45 percent of the material between two consecutive sieve sizes.
  b. The fineness modulus should be between 2.3 and 3.1.
  c. No more than 5 percent of the material should pass the #200 sieve.

Reactivity—A mortar bar containing the aggregate should have an expansion less than 0.10 percent in one year with an 0.8 percent alkali content cement.

Absorption—The absorption should not exceed 3 percent.

Durability—The concrete containing the aggregate should not have a loss in the modulus of elasticity exceeding 50 percent in the freeze-thaw test.

Sand Equivalent—The fine aggregate should have a sand equivalent of not less than 75.

CLASSIFICATION TECHNIQUES USED IN EVALUATING CACHE CREEK DEPOSITS

Evaluation of the Cache Creek deposits was accomplished by petrographic analysis. Analyses of material of otherwise unknown usability for aggregate were compared with analyses of known quality aggregates produced at commercial operations near Yolo and elsewhere in northern and central California. Commercially produced aggregates which have good concrete service records were used as yardsticks to measure the suitability of the undeveloped deposits.

Laboratory Procedures. The examination of the gravels began with a detailed study of the 1½- to ¾-inch fraction. Selection of this grade was a matter of practical convenience as the particle lends itself well to laboratory work. Each pebble in a minimum sized sample of 200 particles was classified according to (1) lithology, (2) physical soundness or strength characteristic, (3) chemical quality, and (4) form, in which two factors, roundness and flatness were considered independently. In practice, in connection with preliminary or reconnaissance type of aggregate investigation, this size sample amounts to all the 1½-inch to ¾-inch pebbles in a pit run sample of about 100 pounds. Experience has shown that for the ordinary stream-bed gravel deposit the size of the sample indicated is sufficient to establish the essential petrographic character and permit classification into groups defining overall physical and chemical soundness and form features. In the case of terrace gravels, or unconsolidated ancient fluviatile sediments where the effects of weathering and cementation may be different in different parts of the deposit, partial analyses of other sizes are also conducted.

FIGURE 14. Method of collecting field sample for petrographic analysis. Portable sieve shaker is used to obtain the $\frac{3}{4}$- to $1\frac{1}{2}$-inch pebbles. This size is the most useful for petrographic study. *Photo by Ben Leafe.*

The lithologic and mineralogic composition, soundness, and form characteristics of the sand fraction were also systematically scrutinized after this fraction had been separated into the sieve sizes conventional for concrete aggregate grading.

Lithologic Classification. In lithologic classification, pebbles and sand grains were set into individual groups based upon lithologic composition. This permitted the complete correlation of the lithology and mineralogy with physical and chemical properties such as soundness, reactivity, shape, and rounding. Attention was focused upon the rocks and minerals of special significance because of their detrimental effect on the concrete-making qualities of the aggregate in which they were included (and at times only partial analyses for these ingredients were made).

Physical Quality (Soundness) Classification. The procedure for testing soundness was to allocate each constituent particle of a sample representing a particular grade size (with emphasis on the $1\frac{1}{2}$- to $\frac{3}{4}$-inch pebble) to one of three categories. A pebble or sand grain was classed as ''good'' and ''satisfactory'' in soundness when it was considered to be stronger than the cement matrix which may be conceived to enclose it, ''fair'' in soundness when it was considered to have about the same strength as normal concrete, and ''poor'' in soundness if it could not utilize the full strength of the cement paste. Each pebble was ex-

amined individually for structural, textural, and compositional features affecting its strength characteristics. Although impact is not a type of stress to which pebbles embedded in concrete are normally subjected, observation of the manner in which the pebble failed under hammer blows (crumbling, splintering, cracking on joints or bedding, etc.) was useful in evaluating the soundness. The classification of the individual pebbles as good and satisfactory, fair, and poor, express the petrographer's opinion of the extent to which they will contribute to or detract from the quality of the concrete; therefore, by determining the proportions of these types present in the deposit an appraisal of the aggregate as a whole can be made. A triangular diagram has been found useful in completing this classification. The triangle is divided into five principal fields representing different degrees of physical soundness, and corresponding suitability for use in concrete. The groups are as follows: A, excellent for use in concrete; B, highly suitable; C, meets the low-medium strength and abrasion-resistance requirements of concrete in moderate climates; D, same suitability as C, but usable only if better material is not economically available; and E, unsuitable.

Chemical Quality Classification. Individual particles were examined for potentially chemically reactive ingredients present in the particles or as exterior coatings. An actual count was made of the number of chalcedonic chert particles present in each grade size. The relative percentages of chert are presented on the petrographic tables. A comparison graph showing the results of special tests made to observe the expansive effects of Franciscan chert, serves as a standard for comparison.

Form Classification (Roundness and Flatness). The form of the pebbles and sand grains comprising an aggregate has a direct bearing on its concrete-making properties. Concrete made with rounded particles requires less cement and work than concrete made with angular fragments. Flatness is one aspect of particle shape of importance in concrete and is independent of the degree of rounding (which is purely a matter of the sharpness of the corners and edges). Flat particles have the same detrimental effect on workability, water, and cement content as do angular particles. There is also a tendency for flat particles to orient themselves horizontally in concrete; this has a harmful effect on bonding because water accumulates beneath the particles. Angularity can contribute to the comparative inferiority of an aggregate, but in itself extreme angularity would not lead to the rejection of an aggregate. The widespread use of quarried crushed rocks where stream deposits do not exist attests to this. In contrast, the degree of flatness of gravel is more critical because satisfactory concrete cannot be made when aggregates contain a large proportion of flat particles. The roundness and flatness generally change with the different grade sizes in a particular aggregate, but there is a different relationship between size and flatness than between size and roundness (Krumblin and Pettijohn, 1938, pp. 277-302). The shape of a particle is determined essentially by its internal structure (lithology and mineralogy, texture, jointing, bedding, foliation, and cleavage) and is generally only slightly modified during the process of transportation. Therefore the proportion in which schistose, foliated, thin-bedded, slaty, platy

jointed rocks, or micaceous minerals occur in the various grades governs the degree of flatness of the sizes.

During stream transport the external form of sedimentary particles is progressively modified, and there are stages in the degree of rounding which provide a natural basis for a three-fold classification of the individual pebbles. When a rock or mineral fragment begins its sedimentary history, its exterior form may be described as being composed essentially of fracture surfaces (including bedding joints and mineral cleavage planes). In respect to the sharpness of corners and edges, or lack of rounding, the particle is no different than a crushed rock fragment. This state of extreme angularity is not restricted to the very early stage in the sedimentary history of the particle. In fact this feature may be outstanding in sand transported tens or even hundreds of miles. One of the processes resulting in diminution of stream-transported pebbles and sand grains is disintegration by cracking and crumbling; thus completely unrounded particles may be continuously forming. Both this fracturing process and rounding by abrasion depend upon the internal structure and size of the particles and on the conditions of stream flow. Ideally angular particles almost imperceptibly rounded may abound in certain size fractions and appear to some extent in all alluvial sediments. In this investigation particles whose edges and corners were slightly rounded but whose external structure was dominated by original fracture surfaces were classified as "angular."

A second natural point in the rounding process is reached when all trace of the fracture surfaces has been removed. Particles at or beyond this stage of rounding were classified as "well rounded;" those particles that had not reached this stage were classed as "intermediate" ("subrounded" and "subangular").

The percentage of particles in each stage is presented in graphical form in a triangular diagram. The proportion of the three types are used to graphically allocate each sample into one of seven broad groups: very well rounded, well rounded, rounded, subrounded, subangular, angular, and very angular.

The procedure followed in classifying particle shape or degree of flatness was very simple. The flat particles were visually separated from those which were not flat. Elongated, spindly, or rod-like pebbles or slender prismatic sand grains have the same harmful effect as excessively flat particles and they were all grouped together in this classification. On the basis of the proportion of flat particles an aggregate was placed into one of four groups: 0-7 percent, equant; 7-15 percent normal; 15-25 percent tabular; and plus 25 percent excessively tabular.

LOWER BASIN DEPOSITS

Quality of Material as Determined by Petrographic Examination

Observations on lithology, physical soundness, chemical quality and form are presented in table 1, *Petrographic analyses of Cache Creek gravel from Rumsey to Yolo,* and are summarized below. Samples 1 and 2 were taken from commercial deposits and served as a standard of comparison for the undeveloped deposits.

Table 1. Petrographic analyses of Cache Creek gravels, from Rumsey to Yolo.

LITHOLOGICAL CLASSIFICATION (Based on counts of 200 to 400 pebbles in the 1½″-¾″ grade and 100 to 200 in the 3″-1½″ grade)		LOWER CACHE: EAST OF YOLO 1	2	3	LOWER CACHE: ES-PARTO 4	5	CAPAY VALLEY 6	7	8	9	10
					In each case, figure above line refers to 1½″-¾″ fraction; figure below line to 3″-1½″ fraction.						
SANDSTONE	Mesozoic unmetamorphosed graywacke, typically well-indurated coarse to fine-grained, often carbonate-cemented, moderately hard, massive, unfractured, slightly to moderately weathered. However, softer deeply weathered or shaly types (15% of total sandstone) are a principal physically unsound constituent. Subrounded to well rounded, with marked tendency to flat shapes.	21	21	23	26 / 32	26 / 27	35 / 36	31 / 33	33 / 37	34 / 39	36 / 44
METASANDSTONE	Mildly to moderately metamorphosed Franciscan graywacke. Typically sub-schistose, cut by quartz veinlets. Subangular to subrounded with tendency toward flat shapes, chiefly physically sound to fairly sound. However, frequent badly fractured, cavernous-veined, deeply weathered types (20% ± of total metasandstone) are the main physically unsound rock type.	32	38	36	35 / 34	32 / 30	30 / 32	31 / 31	31 / 33	30 / 28	32 / 28
QUARTZ VEINLET	Milky quartz from veinlets in metasediments. Angular to subangular, often cavernous with deep re-entrants. Weak, badly fractured pebbles common.	9	8	10	9 / 2	9 / 3	4 / 2	7 / 2	5 / 2	3 / 2	3 / 1
CHERT	Chalcedonic to quartzitic Franciscan radiolarites and meta-radiolarites. Generally very hard and dense, rarely weak and fractured. Subangular to angular. This is the only rock type potentially deleterious chemically at all common in the gravel and sand. See below **Chemical Quality** classification.	18	14	11	12 / 11	7 / 15	9 / 6	10 / 8	6 / 10	6 / 7	2 / 7
METABASIC IGNEOUS	Altered aphanitic Mesozoic volcanics (greenstone). Includes some uralitized gabbroic rocks. Mostly very tough, but weathered fractured types also present. Subrounded.	13	15	16	19 / 12	19 / 13	15 / 16	15 / 16	15 / 13	19 / 17	14 / 11
SERPENTIN(ITE)	Mostly weakened by weathering. An inferior but very minor constituent.	2	2	1	1 / 2	2 / 7	2 / 6	3 / 6	2 / 4	2 / 3	3 / 4
LIMESTONE	Mostly fairly sound dense dark-gray rocks of the type common as thin beds and concretions in Mesozoic shales. Less plentiful are clay-ironstones and unsound chalky porous concretions, probably from Tertiary conglomerates.	--	P	--	P / --	1 / 2	3 / 2	2 / P	5 / P	3 / 4	6 / 3
Granitic rocks, quartzite, metachert, and metavolcanic porphyry	Reworked Mesozoic conglomerate pebbles. Well rounded to subrounded, very hard, weather-resistant rock types.	5	3	1	2 / 3	3 / P	1 / P	P / 2	2 / P	3 / --	1 / 1
Volcanic rocks, basaltic and andesitic.	Unmetamorphosed Tertiary or Recent volcanic rocks. Gray holocrystalline olivine-basalt is most common, hemicrystalline pyroxene andesite very rare.	--	--	--	1 / 2	P / --	--	--	P / --	P / --	--
Amphibolitic metamorphic rocks	Franciscan amphibolitic schist and gneiss. Typically very sound.	--	--	--	--	1 / --	-- / P	-- / P	--	--	P / 1

(NOTE: P = present, but less than one percent.)

PHYSICAL QUALITY CLASSIFICATION (Based on petrographic criteria)										
Good and satisfactory	53	47	50	51	48	52	43	55	51	43
				53	44	49	43	43	42	43
Fair	31	40	39	37	42	34	38	32	32	41
				27	32	34	42	37	41	41
Poor	16	13	11	12	10	14	19	13	17	16
				20	24	17	15	20	17	16
Suitability for use as concrete aggregate based on percentage composition of good, etc., as indicated by plotting on triangular diagram. For meaning of letter symbol see figure 17.	C	C	C	C	C	C	C	C	C	C
					D					
CHEMICAL QUALITY (Based on experimental and geological criteria and service records)										
Percent Chalcedonic Chert										
3''-1½''				11	15	6	8	10	7	7
1½''-¾''	18	14	11	12	7	9	10	6	6	2
¾''-⅜''	10	12	7	7	11	9	5	6	5	4
⅜''-#4	6	10	6	5	4			6	4	5
#8			5	5	5			4	3	
#14	8		5	9	5	6	4	--	5	6
#28	7	5	8	9	7	5	4	7	5	5
#48	5			6						
* Data from analysis of thin sections prepared from sand briquettes. (See figure 18.)										
CLASSIFICATION	Slightly reactive but not enough to require the use of low-alkali cement.									
ROUNDNESS CLASSIFICATION (1½''-¾'')										
Degree of roundness: Well rounded	6	5	4	8	10	9	10	7	6	8
Subrounded and subangular	80	71	86	83	77	77	78	82	76	79
Angular	14	24	10	9	13	14	12	11	8	13
Classification based on percent composition of well rounded, etc., as indicated by plotting on triangular diagram in figure 17. NOTE: Finer grades are progressively more angular.	Subrounded									
FLATNESS CLASSIFICATION										
Percent of sample very flat										
3''-1½''				18	12	25	14	28	26	21
1½''-¾''	19	13	18	20	18	19	13	16	19	16
¾''-⅜''	16	10	15	16	17	9	10	18	20	12

FIGURE 15. Gravel bar on Cache Creek at Rumsey in Capay Valley, view southeast.

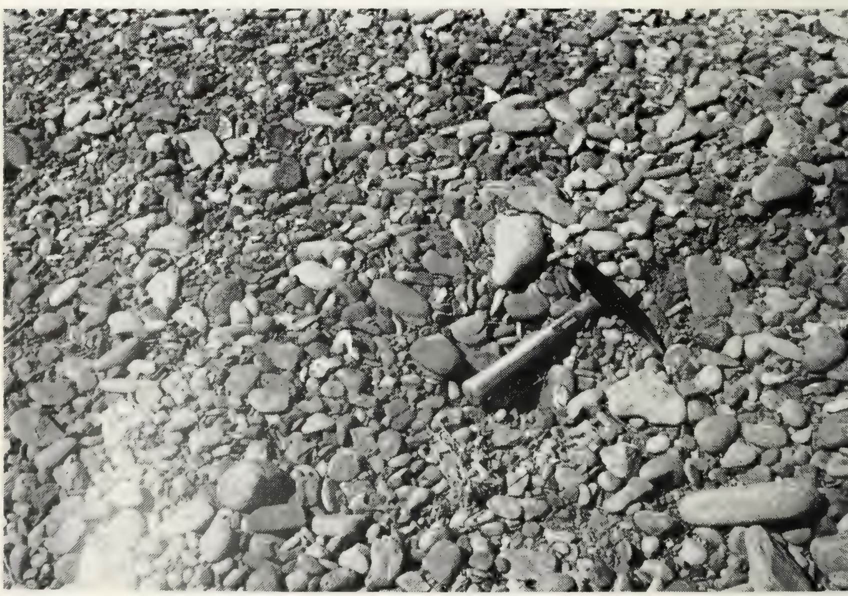


FIGURE 16. Close-up of gravel bar shown in figure 15. The flat, elongated cobbles are sandstone derived from Cretaceous formations. The larger cobbles are weak and break easily when handled.

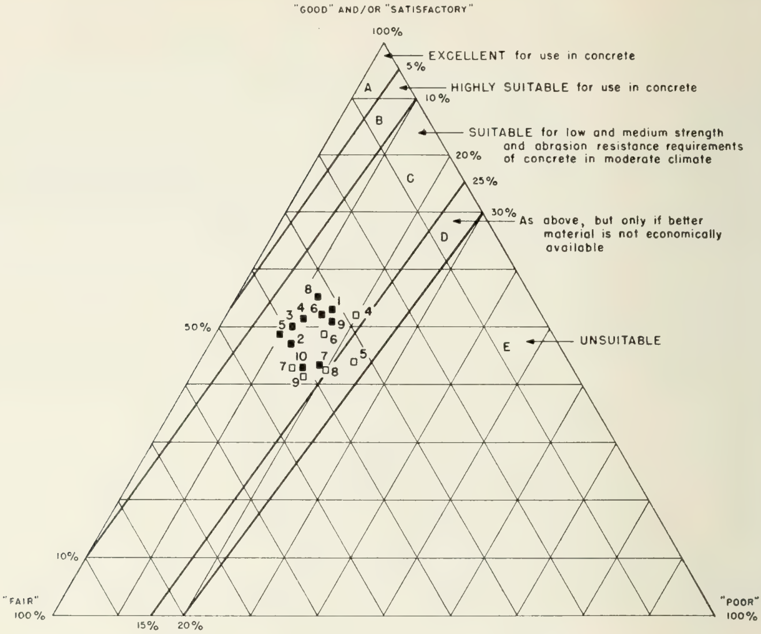
Lithologic Classification. Gravel of the Lower Basin deposits is composed chiefly of metamorphosed and unmetamorphosed graywacke-type sandstone (about 60 percent), metamorphosed basic igneous rock (greenstone) (about 15 percent), chert (from 10 to 18 percent), and quartz veinlets (about 10 percent). The other constituents, none of which exceed 5 percent of the samples, are serpentine, limestone, granitic rocks, metavolcanic porphyries, and amphibolitic metamorphics. The exact percentages of the rock types present in the samples from the individual deposits are presented on table 1. The principal physically unsound rock types are the badly weathered sandstones, the soft serpentines, and the badly fractured quartz veinlets.

The sand (minus #4 sieve size, following aggregate terminology) is highly lithic. Rock particles of the same types mentioned above and in the same general proportion compose the bulk of the sand fraction. Monocrystalline grains of quartz and feldspar, largely derived from the Mesozoic marine sandstones, are the dominant constituents of the fine sand fraction (minus #48 sieve size). Physically unsound grains, of which deeply weathered soft sandstone is the most important, comprise less than 5 percent of the sand. Detailed information about the content of Franciscan chert in the coarse and medium fractions is presented in table 1 in the section on chemical quality. In accordance with the roundness classification used for the gravels, the #8 sand is subrounded, #14 and #28 sub-angular and finer sizes angular. This is a comparatively high degree of rounding for a sand in northern and central California.

A brief study of the very fine fraction (retained on the #200 sieve) showed the following minerals to be present as minor to very sparse constituents: magnetite, ilmenite, chromite, and the chrome-spinel picotite, hornblende, garnet, glaucophane and related sodic amphiboles, clinopyroxene, hypersthene, titanite, epidote, tourmaline, zircon, rutile and leucoxene.

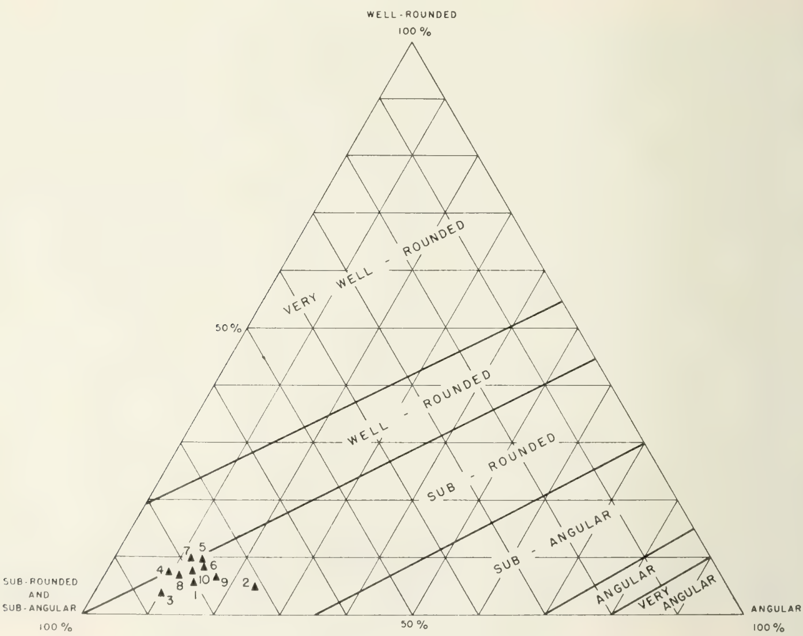
Physical Quality (Soundness) Classification. The undeveloped deposits are comparable with the commercial deposits and all are classified in group C as material that meets the low- and medium-strength and abrasion-resistance requirements of concrete in moderate climate. Approximately half of the pebbles examined in each deposit were of good or satisfactory soundness, 10 to 16 percent were poor, and the remainder were fair. The exact proportions of good and satisfactory, fair, and poor pebbles in the samples from the individual deposits are presented in table 1.

Chemical Quality Classification. The only rock type present in significant amounts in the deposits which is considered potentially chemically reactive is the chalcedonic chert of the Franciscan group. Most of the Franciscan cherts are aggregates of crypto-crystalline or fine granular chalcedony, or very fine mosaics of interlocking quartz grains. In some instances, however, it appears that the cherts have not been crystallized to chalcedony and quartz, or to quartz, and are still largely composed of amorphous silica colored red by iron oxide.



PHYSICAL QUALITY CLASSIFICATION AND COMPARISON DIAGRAM

Numbers refer to samples taken from deposits in Cache Creek between Rumsey and Yolo. Solid squares represent the ¾"-1½" size fraction; open squares represent the 1½"-3" size fraction.



ROUNDNESS CLASSIFICATION AND COMPARISON DIAGRAM

Numbers refer to samples taken from deposits in Cache Creek between Rumsey and Yolo.

FIGURE 17.

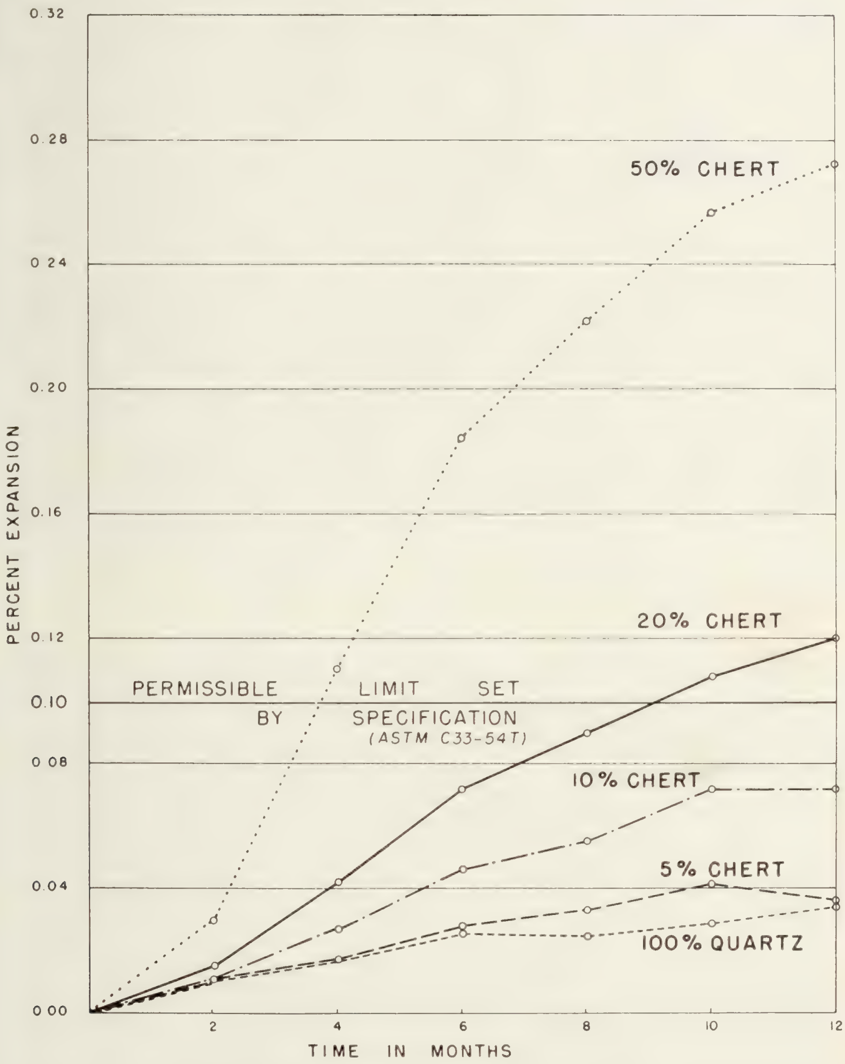


FIGURE 18. Chart of chemical quality, based on experimental and geological criteria and service records; shows percent expansion by months of 1" x 1" x 10" 1:2 mortar bars, sealed with excess moisture at 100° F using cement with 1.30 percent Na_2O and 0.12 percent K_2O and 0, 5, 10, 20, and 50 percent Franciscan chalcedonic chert replacing pure quartz. Tests performed in U. S. Bureau of Reclamation laboratory in Denver, 1947-48, on materials submitted by the Regional Laboratory as typical of this rock found in the California Coast Ranges stream gravels.

FIGURE 19. Commercial operation in stream bed of Cache Creek at Esparto. The sand and gravel is removed by dragline, loaded on bottom-dump trucks and hauled to nearby plant for processing.

FIGURE 20. Close-up of gravel in stream bed shown in figure 19. Pebbles found here range up to 3 inches maximum size.

It has been well established that chalcedonic cherts of diverse origins with variation in textural and mineralogic features are alkali-reactive and their use in concrete aggregate may result in disruptive expansion (Mielenz, R. C., 1946, p. 312). To specifically obtain factual guidance on the effect of the Franciscan cherts, which are widespread in aggregates of the California Coast Ranges, the U. S. Bureau of Reclamation made mortar-bar expansion tests using this material. The tests showed that when high-alkali cement was used, 20 percent of sand-sized Franciscan chert caused an expansion of slightly more than 0.1 percent in a year. The graph showing the results of these tests is reproduced herein. This amount of expansion is just serious enough to cause the aggregate to be classed as deleterious. Very few deposits in California contain more than 15 percent Franciscan chert even in the gravel fraction, where the maximum concentration is invariably found. Commercial deposits in the San Francisco Bay area at Niles, Livermore, Healdsburg, and Tracy contain from 10 to 15 percent chert. These deposits have been used as concrete aggregate for over 45 years. There has been no record of failures of concrete made with these materials because of alkali-aggregate reactivity.

A study by Mr. Goldman has been undertaken to obtain more comprehensive data on service records of concrete made with Coast Ranges aggregate containing Franciscan chert. Preliminary observations indicate that commercial aggregates containing this rock type are not to be viewed with suspicion as being potentially reactive. However, a possible harmful situation in the use of chert may arise when coarse fragments are ground to sand size.

In the Cache Creek gravel, a concentration of from 14 to 18 percent chert was found in the 1½- to ¾-inch gravel in the commercial deposits. The undeveloped deposits contain a lesser amount (7 to 15 percent) of chert in this fraction. The chert content decreases progressively with decrease in grain size. In the #48 screen size only 5 percent chert was noted. The actual percentages of chert in each deposit are presented in table 1.

Form Classification (Roundness and Flatness). The pebbles in the Lower Basin deposits are predominantly subrounded to subangular. Well-rounded pebbles comprise less than 10 percent, and angular pebbles from 10 to 25 percent, of the total sample. According to the classification scheme, the aggregates from all the deposits are considered to be subrounded.

The proportion of very flat pebbles ranges from 10 to 15 percent in the ¾- to ⅜-inch size and from 13 to 19 percent in the 1½- to ¾-inch size. The actual percentages of very flat pebbles in each deposit are presented in table 1.

Quality of Materials as Determined by Routine Laboratory Tests

Standard acceptance tests on samples taken near Rumsey, Brooks, Esparto, and Madison were performed by the U.S. Bureau of Reclamation prior to approval of their use in the Monticello dam and other features of the Solano project. It was concluded that sand and gravel from the lower reaches of Cache Creek were suitable for use in air-

FIGURE 21. Excavation in stream bed of Cache Creek at Yolo. Sand lens is interbedded in gravel. *Photo by Ben Leafe.*

FIGURE 22. Close-up of sand and gravel in cut shown in figure 21. Maximum size of gravel is 1½ inches. Sand content estimated to be 60 percent.

entrained concrete for mass structures provided they were washed and properly graded. The materials from the deposit at Rumsey were found to be inferior to the other samples. A summary of the results of the Bureau of Reclamation tests is presented below (U.S. Bur. Reclamation Concrete Lab. Rept. C-727, Laboratory tests of concrete aggregate, Monticello Dam—Solano Project, Denver, Colo., 1953).

Grading, Specific Gravity, Absorption and Abrasion. The deposits contain 26 to 44 percent sand, and 11 to 23 percent 3- to 6-inch rock in the gravel. The sands are coarsely graded and contain a moderate amount of silt. Additional processing or blending with a fine sand is

Table 2. Gradation, specific gravity, and absorption test results of Lower Basin deposits of Cache Creek.

	CAPAY VALLEY				ESPARTO				MADISON
	Rumsey		Brooks						
Map reference letter	A	B	C	D	E	F	G	H	I
Depth (feet)	0-7	0-7	0-7	0-7	2-7#	0-10	0-10	0-10	0-4
Gravel Grading									
Combined cumulative percent retained									
6″	8	0	0	0	0	0	0	0	0
3″	25	12	2	6	7	1	13	5	0
1½″	41	26	5	14	15	8	29	18	6
¾″	55	40	16	28	27	24	44	35	22
⅜″	66	52	31	44	45	42	58	53	42
#4	74	61	47	56	58	58	70	68	60
Sand Grading									
Percent sand	26	39	53	44	42	43	30	32	40
Cumulative percent retained									
#8	17	16	22	27	23	22	26	20	23
#16	37	35	40	47	44	43	50	41	50
#30	59	63	59	69	65	65	70	61	62
#50	79	86	84	88	88	83	84	81	74
#100	91	95	97	96	97	91	89	89	84
Pan	100	100	100	100	100	100	100	100	100
Percent silt in sand	6.2	4.3	2.4	2.5	2.4	7.7	8.5	9.6	10
Specific Gravity									
(Saturated surface dry)									
3″-1½″	2.63	2.63	2.66	2.66	2.69	2.69	2.69	2.69	
1½″-¾″	2.68	2.68	2.67	2.69	2.68	2.68	2.70	2.70	
¾″-⅜″	2.67	2.66	2.67	2.68	2.68	2.68	2.68	2.69	
⅜″-#4	2.68	2.66	2.68	2.68	2.69	2.69	2.69	2.69	
Sand	2.68	2.70	2.74	2.75	2.74	2.72	2.72	2.70	
Absorption Percent									
3″-1½″	1.9	1.9	1.3	1.3	1.9	0.9	0.9	0.9	
1½″-¾″	1.5	1.85	1.5	1.1	1.2	1.0	1.2	0.9	
¾″-⅜″	1.1	1.6	1.3	1.1	1.0	1.0	1.3	0.9	
⅜″-#4	0.95	0.9	0.7	0.6	0.8	1.0	0.9	0.6	
Sand	1.1	1.9	0.4	0.4	1.0	1.2	0.85	1.3	

\# 0-2′ Sandy overburden, not included in sample.

Grading data on samples A-H based on U. S. Bureau of Reclamation, Sacramento, laboratory screening of 700-1100 pound samples. I is based on information from California Div. Highways, typical of local streambed material used in roadwork.

*Table 3. Mechanical analyses, organic content, specific gravity, and absorption of sand in Lower Basin deposits of Cache Creek.**

Sample	Cache Creek pit run						Cache Creek washed					
Standard screen size	Deposit G 2 miles N of Esparto		Deposit D 4 miles NW of Brooks		Deposit A 2 miles SE of Rumsey		Deposit G 2 miles N of Esparto		Deposit D 4 miles NW of Brooks		Deposit A 2 miles SE of Rumsey	
	Percent ret.	Cum. percent	Percent ret.	Cum. percent	Percent ret.	Cum. percent	Percent ret.	Cum. percent	Percent ret.	Cum. percent	Percent ret.	Cum. percent
No. 4	0	0	0	0	0	0	0	0	0	0	0	0
No. 8	30	30	25	25	21	21	33	33	24	24	25	25
No. 16	27	57	22	47	24	45	28	61	22	46	25	50
No. 30	21	78	22	69	24	69	20	81	24	70	25	75
No. 50	14	92	20	89	19	88	12	93	21	91	17	92
No. 100	5	97	7	96	7	95	5	98	7	98	6	98
Pan	3	100	4	100	5	100	2	100	2	100	2	100
Fineness modulus	3.54		3.26		3.18		3.66		3.29		3.40	
Color test	No. 1		No. 1		No. 1		----		----		----	
Percent silt content	7.4		3.1		4.17		----		----		----	
Specific gravity	2.68		2.65		2.64		2.69		2.67		2.66	
24-hour absorption, percent	1.6		2.0		2.0		1.1		1.4		1.6	

* Data from U. S. Bureau of Reclamation tests.

required to meet federal specifications. The gravels are above average in specific gravity, have low absorption, and exhibit low abrasion losses in the Los Angeles rattler test. Preliminary gradings, specific gravity, and absorption of the sand as determined by the Bureau of Reclamation Sacramento laboratory are presented in table 2.

Organic Content Test. Sand from Cache Creek contains moderate amounts of silt and requires washing; however, none of the sand contains harmful amounts of organic material as indicated by the organic color test. Organic content test results are presented in table 3.

Soundness (Sodium Sulfate) Test. The sodium sulfate soundness test was performed on the sand and gravel from three deposits. Sand and gravel from deposits at Brooks (D) and Esparto (G) have low losses within specification limits.

Sand and gravel from a deposit at Rumsey (A) have losses slightly higher than specification limits and are inferior to the other two samples. Results of the tests are presented in table 4.

*Table 4. Soundness of aggregate from Lower Basin deposits of Cache Creek.**

Sodium sulfate soundness tests weighted percent loss 5 cycle.

Particle size	Typical grading percent	Cache Creek		
		Deposit G 2 miles N of Esparto	Deposit D 4 miles NW of Brooks	Deposit A 2 miles SE of Rumsey
Sand				
No. 4 to No. 8	20	0.7	1.5	1.9
No. 8 to No. 16	20	0.4	0.7	1.8
No. 16 to No. 30	30	0.7	1.1	2.3
No. 30 to No. 50	30	1.0	1.7	3.2
Total	100	2.8	5.0	9.2
Gravel				
1½″ to ¾″	50	4.7	1.5	5.2
¾″ to ⅜″	30	3.2	1.9	5.7
⅜″ to No. 4	20	1.3	2.1	2.8
Total	100	9.2	5.5	13.7

* Data from U. S. Bureau of Reclamation tests.

Soundness (Freeze-Thaw) Test. Concrete cylinders made with sand and gravel from Brooks, Esparto, and Rumsey were subjected to freezing and thawing durability tests. Alternate freezing and thawing was continued until the specimens lost 25 percent of their original weight or until 1000 cycles were obtained. Results indicated that all the concrete made with Cache Creek aggregate withstood 1000 cycles of freezing and thawing and had weight losses of 16 to 18 percent, which is considered excellent durability. Compressive strength was very good.

Alkali Reactivity (Mortar-Bar Expansion) Test. Mortar-bar tests were also made to determine if the sands and gravels from Cache Creek would react with alkalies in cement to produce deleterious expansion. After 12 months, test results indicated that no reactive rock types were

Table 5. Alkali-aggregate reactivity tests

Mix parts by weight—1:2.00

Aggregate source	Cache Creek deposit G 2 miles north of Esparto							
Material	Sand				Gravel			
Cement no.	9406	7488	7488	7488	9406	7488	7488	74
Equivalent soda in cement, percent	0.17	1.19	1.19	1.19	0.17	1.19	1.19	1.
Test aggregate, percent	100	100	50	25	100	100	50	
Neutral aggregate, percent	0	0	50	75	0	0	50	
Age								
1 month	—0.003	0.008	0.015	0.014	—0.002	0.011	0.012	0.0
3 months	—.004	—.009	.017	.018	—.003	.014	.016	.0
6 months	—.002	.017	.029	.029	—.001	.021	.027	.0
9 months	—.002	.026	.041	.039	—.001	.030	.035	.0
12 months	—.003	.018	.043	.043	—.003	.029	.035	.0

* If any combination of test aggregate and high-alkali cement develops an expansion of 0.10 percent within 12 mont
the aggregate is considered reactive and a low-alkali cement or an effective combination of portland cement and p
zolan must be used.

** Data from U. S. Bureau of Reclamation tests.

FIGURE 23. Schwarzgruber and Sons sand and gravel plant. Pit run material is simply washed and screened to produce concrete aggregate.

er Basin deposits of Cache Creek. **

d in moist air at 100° F.

Cache Creek deposit D 4 miles northwest of Brooks								Cache Creek deposit A 2 miles southeast of Rumsey							
Sand				Gravel				Sand				Gravel			
)6	7488	7488	7488	9406	7488	7488	7488	9406	7488	7488	7488	9406	7488	7488	7488
17	1.19	1.19	1.19	0.17	1.19	1 19	1.19	0 17	1.19	1.19	1.19	0.17	1.19	1.19	1.19
)0	100	50	25	100	100	50	25	100	100	50	25	100	100	50	25
0	0	50	75	0	0	50	75	0	0	50	75	0	0	50	75
Expansion—percent*															
04	0.015	0.011	0.003	—0.003	0.009	0.010	0.011	—0.015	0.013	0.013	0.015	—0.001	0.014	0.014	0.013
05	.016	.016	.020	—.003	.015	.015	.017	—.006	.021	.017	.019	—.002	.018	.019	.017
01	.033	.038	.033	.002	.036	.037	.035	.000	.047	.042	.037	.001	.031	.034	.034
01	.034	.051	.037	—.002	.040	.047	.037	—.001	.048	.055	.043	—.002	.035	.037	.041
04	.050	.070	.038	—.004	.044	.056	.042	—.005	.047	.063	.045	—.007	.033	.034	.042

present in the sand and gravel in any of the deposits. Results of the mortar-bar tests are given in table 5.

Alkali Reactivity (Chemical Quality) Test. The quick chemical test for alkali reactivity was applied to the sands and appropriately graded samples of the gravels and gave the following results:

Sample	Silica release (Sc) millimoles per liter		Reduction in alkalinity (Rc) in millimoles per liter	
	Gravel	Sand	Gravel	Sand
G Esparto	58	72	94	113
C Brooks	66	69	92	124
A Rumsey	43	74	148	142

These results indicate the sand and gravel are not sufficiently reactive to be considered deleterious.

Division of Highways Tests. Cache Creek aggregates have been used for many years on state highways. From 1948-54, the Materials and Research Laboratory in Sacramento conducted standard acceptance tests for soundness, absorption, specific gravity, abrasion, and organic content on sand and gravel from commercial deposits near Yolo and Madison. The results, which are summarized in table 6, indicate that these materials are within the specification limits for concrete aggregate.

Economic Possibilities

Volume of Available Material. The roughly estimated quantities of sand and gravel economically available in deposits in the Lower Basin are tabulated below. These estimates give only the order of size as no drilling or geophysical work was done to determine the depth of the deposits.

*Table 6. Results of tests on commercial deposits on Cache Creek near Yolo and Madison.**

Location of commercial deposit		Soundness (wt. av. Na_2SO_4 percent loss)		Specific gravity		Absorption		Abrasion (coarse aggregate)		Organic
		Fine	Coarse	Fine	Coarse	Fine	Coarse	100 rev.	500 rev.	
Yolo	1	1.4—3.2	1.2—3.4	2.59—2.79	2.63—2.67	1.3—1.7	0.9—1.1	4.4—6.0	20.4—23.4	1+
	2	2.61	2.18	2.67	2.65	1.5	1.0	4.9	22.4	
	1	2.5—2.7	1.1—1.6	2.63—2.73	2.63—2.70	1.2—1.5	0.9—1.0	6.5	22.2	1+
	2	2.6	1.4	2.68	2.67	1.4	1.0			
	1	3.4	1.7—1.8	2.59—2.63	2.66—2.70			4.6	22.2—22.7	1+
	2		1.75	2.61	2.68			4.6	22.5	
Madison	1	2.1—2.5	1.7—3.1	2.61—2.62	2.63—2.67	1.6—1.7	0.9—1.5	5.1—5.2	23.8	1+
	2	2.3	2.1	2.62	2.66	1.6	1.2	5.2	23.8	

* Tests made by California Division of Highways.
[1] Range of test results—nuumber of tests varied from 3 to 10.
[2] Average of test results.

Table 7. Rough estimates of volume of sand and gravel available for aggregate in Cache Creek from Rumsey to Yolo.

Location	Est. cu. yds.	Overburden	Relation to water table	Gradation	Remarks
(1) Vicinity Rumsey	3 million	Very light stripping; sparse vegetation	Half materials available below summer water table	3″ and 6″ maximum size (see table 2)	Subject to flooding
(2) Vicinity Brooks	5 million	Little stripping; sparse vegetation	Half materials available below summer water table	Little 3″ maximum size (see table 2)	Subject to flooding
(3) Esparto to Madison	1 million cu. yds. per mile	Little or no stripping	Materials available above water table during summer and early fall seasons	3″ and 6″ available at Esparto; progressively finer downstream (See table 2)	Superabundance of medium and fine gravels and sands
(4) Vicinity Yolo	1 million cu. yds. per mile	Little or no stripping	Material available above water table during summer and early fall seasons	+1½″ gravel content extremely low; estimated 60 percent sand	Replenished during floods

Commercial Production. Commercial production has centered on the lower reaches of Cache Creek near the towns of Yolo and Madison in the Sacramento Valley. In 1955, six sand and gravel operators produced 878,698 tons of sand and gravel valued at $806,218. Materials are excavated from the center of the stream bed by power shovel, usually to a depth of 15 feet, and loaded on truck or carryall for transport to the plants. The sand and gravel is stockpiled to be processed during times of high water. Ordinarily the excavated material is replenished by flood waters which redistribute sand and gravel along the channel from the adjoining floodplain deposits.

The processing of the aggregate is relatively simple, requiring no special beneficiating equipment. No clay balls are present and one operator merely washes and screens the material to size. Other plants use crushers for plus $1\frac{1}{2}$ inch gravel, and sand classifiers to clean the sand. Descriptions of the commercial operations are summarized in table 8. The plants are located in an area where the largest size gravel is $1\frac{1}{2}$ inches, and there is an abundance of sand, estimated at 60 percent of the deposit. A large portion of the sand is shipped to the Sacramento area to other company-owned plants. This sand in some instances is harsh, because of the presence of sharp, lithic fragments, and is blended with American River sand. Water is obtained from wells averaging 200 feet in depth adjacent to the stream.

Non-Commercial Production. Approximately 500,000 tons of gravel and 125,000 tons of sand were removed from Cache Creek for use as

Table 8. Sand and gravel producers on Cache Creek in 1956.

Name	Location	Plant	Products	Reported capacity
Schwarzgruber	Yolo	Screening and washing	Sand and gravel for concrete aggregate to ready-mix operators	25 cu. yds./hr.
Pacific Cement and Aggregates	Yolo	Portable crusher, screening and washing, sand screw	Sand and gravel for concrete aggregate to own ready-mix plants; crushed rock for road base	About 160 tons/hr.
A. Teichert	Yolo	Crushers, screening and washing, sand scrubber, hot plant	Sand and gravel for concrete and bituminous aggregate; crushed rock for road base	About 100 tons/hr.
Granite Construction Co.	Yolo	Crusher, screening and washing, hot plant	Sand and gravel for concrete and bituminous aggregate; crushed rock for road base	About 100 tons/hr.
Madison Sand & Gravel	Madison	Cone crusher, washing and screening plant, sand screen	Sand and gravel for concrete aggregate to own ready-mix plants, crushed rock for concrete pipe and road base	About 200 tons/hr.
Madison Sand & Gravel	Esparto	Washing and screening plant, sand wheel, cyclone Doodle-bug dredge with trommel and washer to obtain large size aggregate (3-6″) for concrete at Monticello Dam	Sand and gravel for concrete aggregate to ready-mix plants and Travis Air Force Base, Fairfield, and Monticello Dam	2,500 to 4,000 tons/day

concrete aggregate in the construction of Monticello Dam. Probably an equal amount will be used in the construction of the Putah south canals and other features of this project. The dam, which is situated on Putah Creek 9 miles west of Winters, was put into construction in 1954 by the U. S. Bureau of Reclamation and was completed in early 1957. The design of the concrete arch dam called for the following gradation of aggregate:

	Size	Percent of total aggregate		Screen no.	Individual percent by weight retained on screen
GRAVEL	6″	22	SAND	4	0-5
	3″	21		8	5-20
	1½″	19		16	10-20
	¾″	17		30	10-30
	sand	21		50	15-35
				100	12-20
				pan	3-7

The 3- to 6-inch aggregate used in the dam construction did not come from Cache Creek but from pits in gravel deposited by the American River a few miles east of Sacramento. This was because of the

FIGURE 24. Madison Sand and Gravel Co. plant at Madison processes sand and gravel for concrete aggregate, and, in crushed form, for concrete pipe and road base. *Photo by E. S. Ensor, courtesy U. S. Bureau of Reclamation.*

general deficiency of coarse gravel in the Cache Creek deposits and the relative inferiority in physical quality of such material as did occur in those sizes. Preliminary studies indicated that the gravel over 1½ inches might have to come from the American River. However, by shifting operations upstream from Madison to Esparto, the Madison Sand and Gravel Company found it economical to produce all the 1½- to 3-inch material from Cache Creek.

FIGURE 25. Madison Sand and Gravel Co. plant at Esparto. This plant was built specifically to process aggregate for use in Monticello Dam.

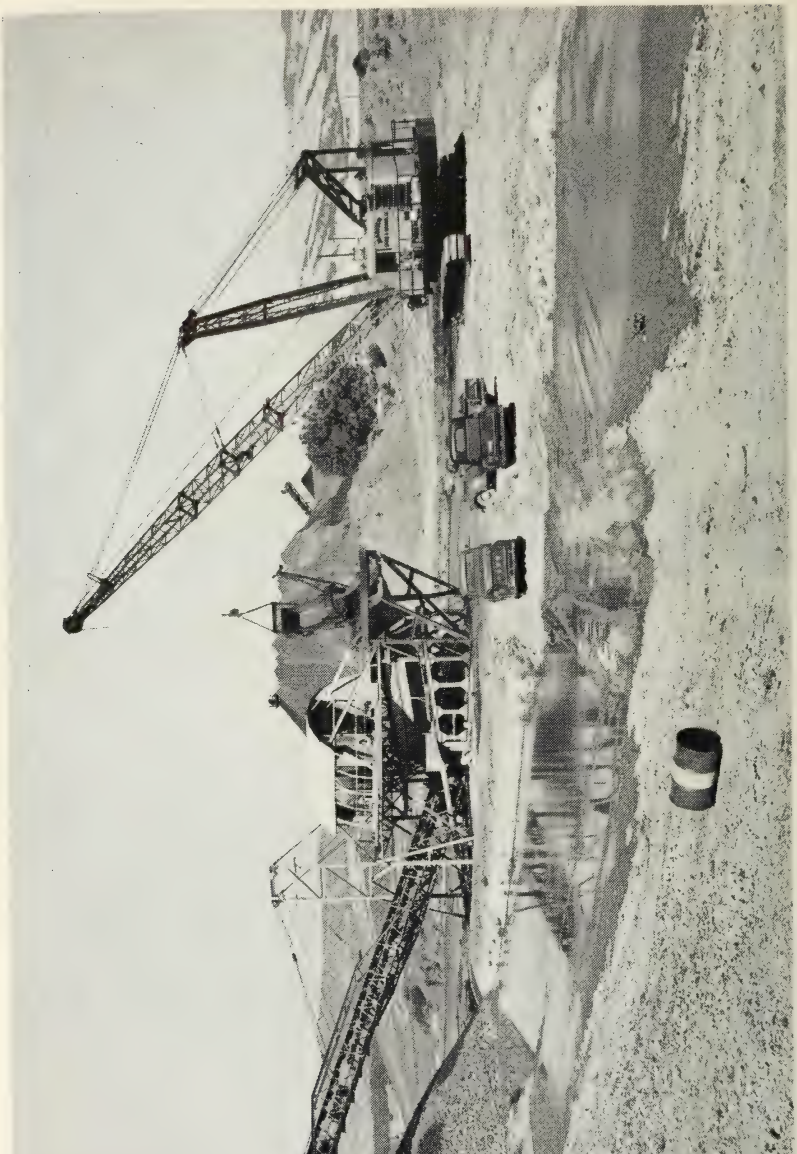


FIGURE 26. Doodle-bug dredge used by Madison Sand and Gravel Co. at Esparto to obtain coarse aggregate for use in Monticello Dam. All gravel larger than $\frac{7}{8}$-inch was removed and placed along dredge; the minus $\frac{7}{8}$-inch fraction was returned to the pond. *Photo by E. S. Ensor, courtesy U. S. Bureau of Reclamation.*

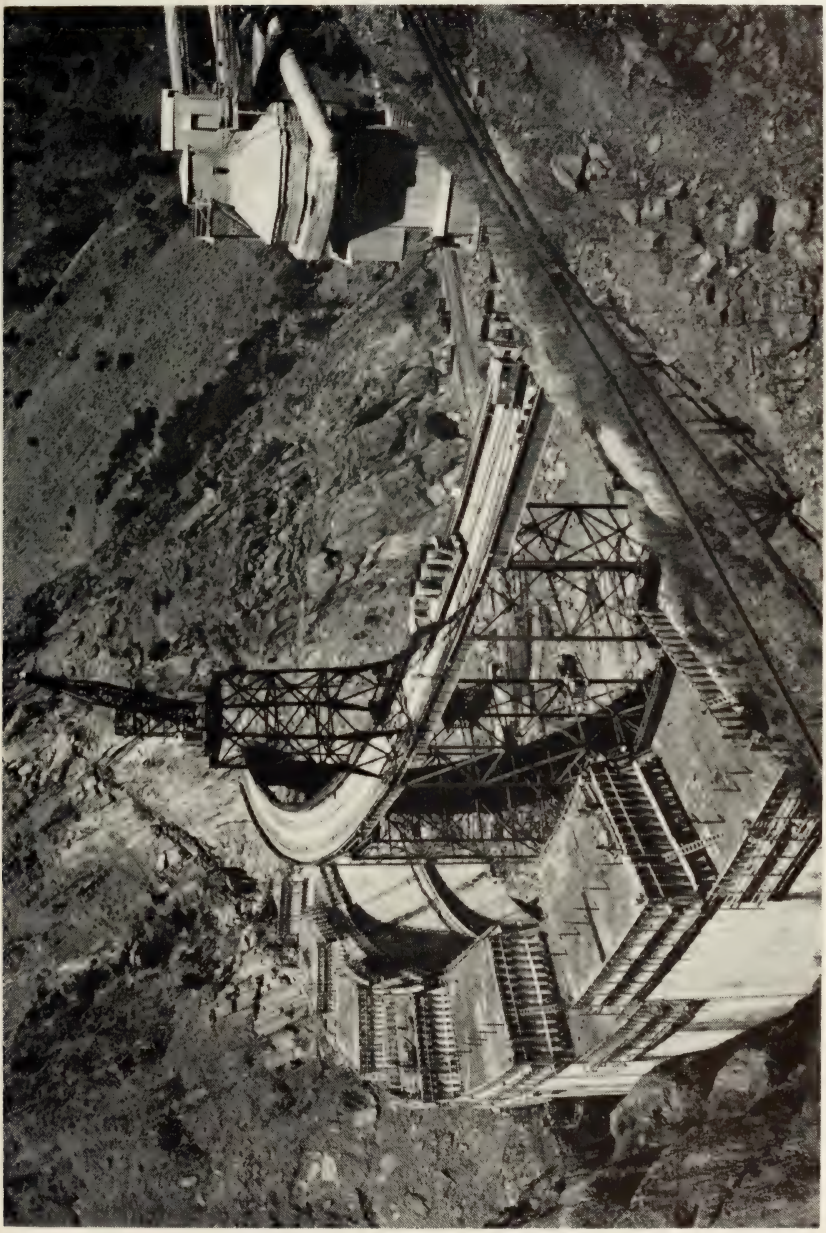


FIGURE 27. Monticello Dam during construction in 1956. Concrete was mixed in batch plant at extreme right and placed in buckets which were delivered by rail to a crane on trestle that lowered bucket for pouring. *Photo by B. D. Glaha, courtesy U. S. Bureau of Reclamation.*

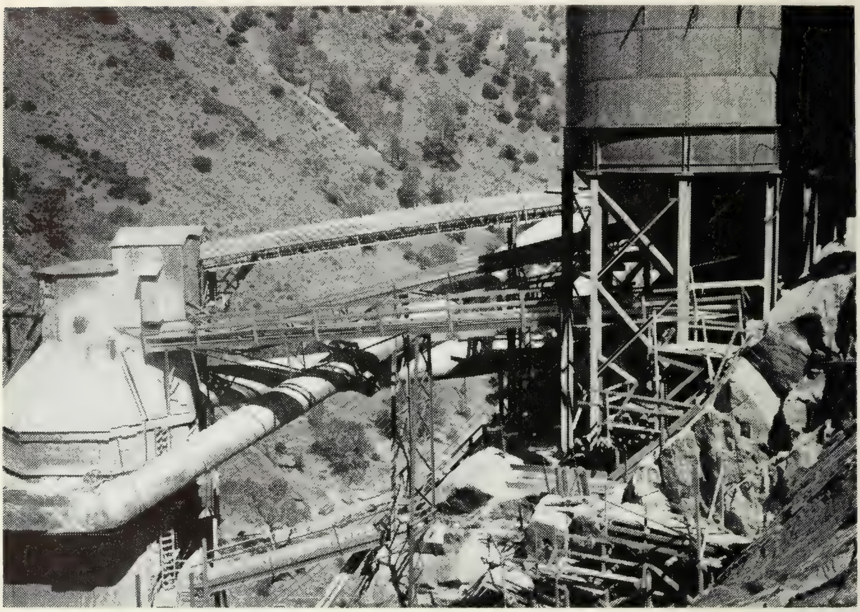


FIGURE 28. Close-up of concrete batch plant shown in figure 27. Concrete was mixed automatically. Aggregate and cement were trucked to the plant and fed by conveyor belt. *Photo by E. S. Ensor, courtesy U. S. Bureau of Reclamation.*

FIGURE 29. Workmen emptying concrete from bucket during construction at Monticello Dam. *Photo by E. S. Ensor, courtesy U. S. Bureau of Reclamation.*

FIGURE 30. Vibrating concrete after pouring (see figure 29) in construction of Monticello Dam. *Photo by E. S. Ensor, courtesy U. S. Bureau of Reclamation.*

FIGURE 31. Stream bed of North Fork Cache Creek in northern end of Indian Valley; view west.

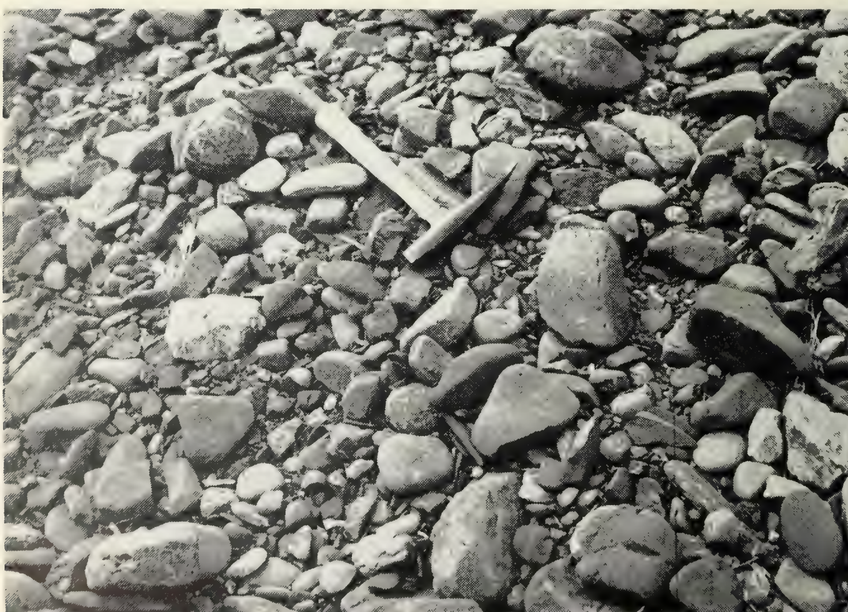


FIGURE 32. Close-up of gravel in stream bed shown in figure 31. This deposit contains excessive proportion of flat pebbles.

The sand fraction was obtained from the company-owned plant at Madison. In order to comply with the Bureau's rigid sand specifications, this plant was equipped with 25- and 15-inch wet cyclones to recover the extreme fines from the overflow of the sand classifiers.

The specifications for the concrete mix called for the following quantity of materials per cubic yard of concrete: cement 213 lbs., pozzolan 70 lbs., sand 765 lbs., and gravel 2955 lbs. Type II (sulfate resistant) cement was used with a pozzolan, a calcined diatomaceous shale which was obtained from the Basalt Rock Co. quarry located about 3 miles northwest of Napa.

Marketing. The present market area for sand and gravel produced from Lower Cache Creek deposits includes Solano and Yolo Counties and portions of Colusa and Sutter Counties. A significant proportion of sand is marketed in the Sacramento area. Truck-haul distances range up to 30 miles. There are rail facilities available at Esparto, Madison, and Yolo. A good haulage road, state Highway 16, parallels the stream from Esparto to Rumsey.

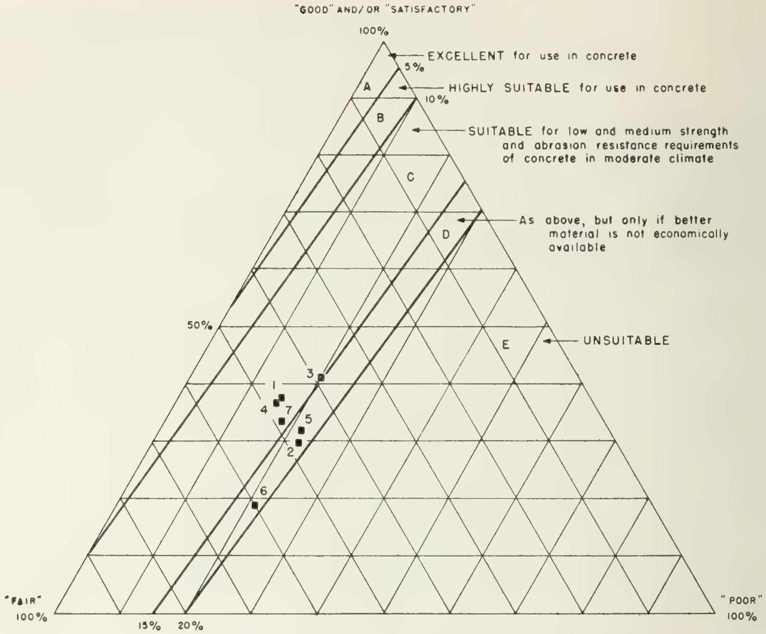
UPPER BASIN DEPOSITS

Quality of Materials as Determined by Petrographic Examination

A reconnaissance field examination and a petrographic examination indicate that concrete aggregate may be developed in the Upper Basin mainly in the alluvial plain of North Fork Cache Creek from its point of confluence with Long Valley Creek southward to its junction with the main branch, a distance of about 7 miles. Gravel bars of comparable quality also occur along the main branch between this junction and the upper end of Wilson Valley. In Indian Valley, some parts of the extensive gravel deposits along the North Fork are of at least marginal aggregate quality. The usable deposits are outlined on the accompanying map showing the aggregate resources of North Fork Cache Creek and Cache Creek above Wilson Valley.

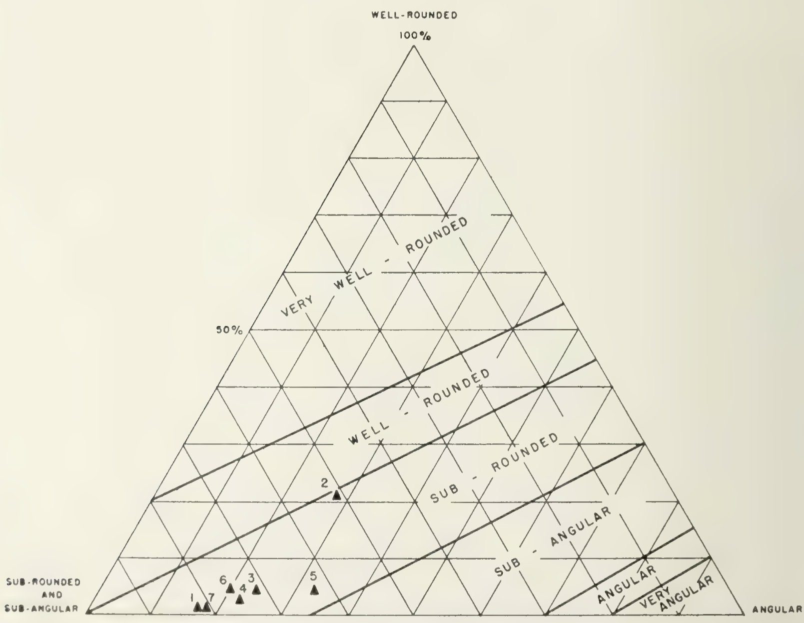
Flat pebbles were found to characterize the gravels of the North Fork between the mouth of Long Valley Creek and Chalk Mountain and in the upper end of the Indian Valley deposits. In any future large-scale development of aggregate in this area, the presence of flat pebbles will be a factor which will be of concern. However, processing methods have been developed in similar circumstances to beneficiate gravels containing excessive amounts of flat pebbles. In the northern end of Indian Valley the minor eastern tributary Stanton Creek contributes excessive amounts of unsound serpentine to the North Fork deposits, at the confluence of the streams and possibly for a few miles to the south. The gravel bars in Stanton Creek and in North Fork Cache Creek that contain this unsound serpentine are not suitable for concrete aggregate. Sample No. 6 at the south end of Indian Valley contains a negligible amount of unsound serpentine from Stanton Creek. Systematic petrographic study would readily delineate the contaminated interval.

In the upper end of Wilson Valley, Rocky Creek is also depositing large amounts of unsound serpentine detritus on an alluvial fan bordering Cache Creek. However, this is a short distance below the main alluvial deposits of Cache Creek that have concrete aggregate potentialities.



PHYSICAL QUALITY CLASSIFICATION AND COMPARISON DIAGRAM

Numbers refer to samples taken from the deposits in North Fork Cache Creek.



ROUNDNESS CLASSIFICATION AND COMPARISON DIAGRAM

Numbers refer to samples taken from the deposits in North Fork Cache Creek

FIGURE 33.

FIGURE 34. Stream bed of North Fork Cache Creek in southern end of Indian Valley; view south.

FIGURE 35. Close-up of gravels in stream bed shown in figure 34. Samples from this deposit show it to be at least of marginal quality for use as concrete aggregate.

Table 9. Petrographic analyses of North Fork Cache Creek gravel.

LITHOLOGICAL CLASSIFICATION (Based on counts of 200 pebbles in each sample)		Location of stream sample						
		South of bridge across Hwy. 20	Along Hwy. 20	Near Benmore Canyon	Near Long Valley Creek	Near Chalk Mountain	Indian Valley: South end of valley	Indian Valley: Above Stanton Creek
		Map reference number						
		1	2	3	4	5	6	7
		PERCENTAGES (Figure above line refers to 1½''-¾'' fraction; figure below line to ¾''-⅜'' fraction)						
METASANDSTONE	Franciscan group feldspathic graywacke well indurated through slight metamorphism, fine to medium grained, generally massive but some is sub-schistose, chiefly physically sound. Generally shows little weathering; however, the softer, deeply weathered, badly fractured types are physically unsound. Subangular to subrounded with a marked tendency to flat shapes.	61	52	64	60	65 / 52	43	60
SLATY METASEDIMENTARY ROCKS	Well-indurated and mildly metamorphosed argillitic and silty sedimentary rocks of the Franciscan group, fractured, brittle, platy often fissile, tending to split on bedding laminae, subrounded, fairly sound.	2	3	5	6	8 / 13	7	10
METASEDIMENTARY ROCKS WITH QUARTZ VEINLETS	Mildly metamorphosed Franciscan group graywacke, crisscrossed with irregular honeycomb often leached, quartz veinlets. Often highly cavernous with deep open fractures. Angular to subrounded. This is the principal physically unsound rock type.	12	18	12	14	11 / 6	39	12
QUARTZ VEINLET	Milky quartz derived from veinlets in metasediments, angular to subangular. Generally tough and durable, but weak weathered pebbles with deep open fractures in which iron oxides have been deposited are common.	4	13	6	6	7 / 19	1	6
METABASIC IGNEOUS GREENSTONE	Slightly to moderately altered, pre-Tertiary (probably Franciscan group) shallow intrusive and volcanic flow rocks (basaltic in composition) usually very tough, well	13	13	10	8	6 / 8	6	8

	to subrounded, fairly sound; includes some highly altered chloritic, amphibolitic gabbroic rocks with relict igneous textures that are fractured and weathered and generally unsound.							
CHERT	Chalcedonic to quartzitic Franciscan group radiolarites and metaradiolarites, many with numerous quartz veinlets. Generally hard and dense, rarely weak and fractured, subangular to angular.	3	--	1	3	1 – 1	2	1
SERPENTINE	Metamorphosed ultrabasic intrusives, massive but physically unsound because of fractures and intense weathering; soft, well rounded; an inferior constituent.	P	1	P	P	2 – P	2	P
AMPHIBOLITIC METAMORPHIC ROCKS	Franciscan group amphibolitic schists and gneisses, subrounded, fairly sound.	2	P	1	P	1	P	2
Volcanic rocks	Unmetamorphosed Tertiary or Recent volcanics, basaltic in composition, fairly sound, subrounded.	P						
Limonite	Ferruginous concretions (?) deeply weathered, subrounded, soft, physically unsound.	2						
Conglomerate	Caliche-cemented gravels of the Cache formation, weak, poorly indurated.	1						
		(Note: P – present, but less than one percent)						
PHYSICAL QUALITY CLASSIFICATION (Based on petrographic criteria)								
Good and satisfactory		38	30	41	38	32	19	34
Fair		46	47	39	47	46	60	47
Poor		16	23	20	15	22	21	19
Suitability for use as concrete aggregate based on percentage composition of good, etc., as indicated by plotting on triangular diagram. For meaning of letter symbol see figure 33		C	D	C	C	D	D	C
CHEMICAL QUALITY								
Percent chalcedonic chert		3	--	1	3	1 – 1	2	1
CLASSIFICATION		Nonreactive						
ROUNDNESS CLASSIFICATION								
Degree of rounding: well rounded		2	21	4	3	4	4	2
Degree of rounding: subrounded and subangular		82	52	72	75	63	76	81
Degree of rounding: angular		16	27	24	22	33	20	17
Classification based upon percent composition of well rounded, etc., as indicated by plotting on triangular diagram in figure 33		subrounded					subrounded	
Note: Finer grades are progressively more angular.								
FLATNESS CLASSIFICATION								
Percent of sample very flat 1½″-¾″		20	11	21	24	26	20	30
¾″-⅜″		22			22	28		
⅜″-#4		14			25	32		

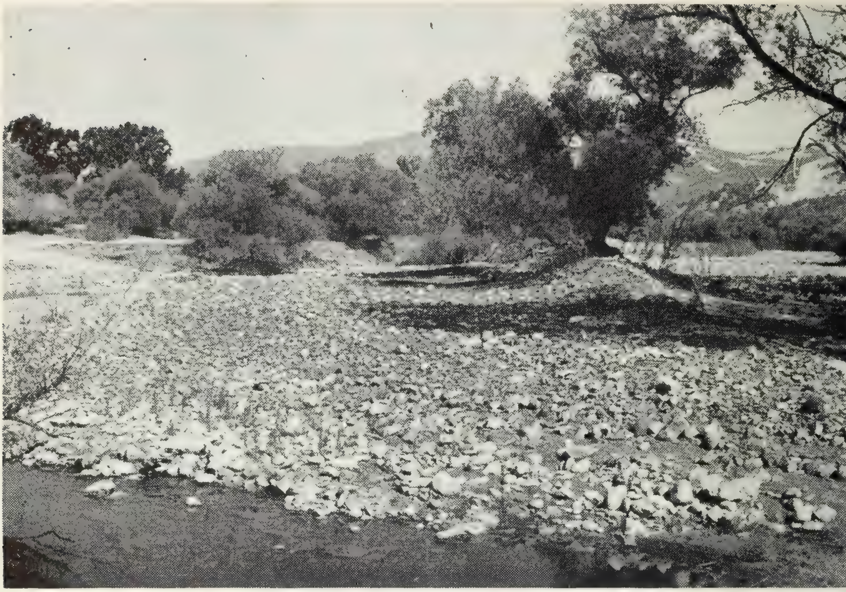


FIGURE 36. Stream bed of North Fork Cache Creek near state Highway 20; view north.

FIGURE 37. Stream bed of North Fork Cache Creek along state Highway 20; view northwest.

FIGURE 38. Stream bed of North Fork Cache Creek, downstream from figure 37.

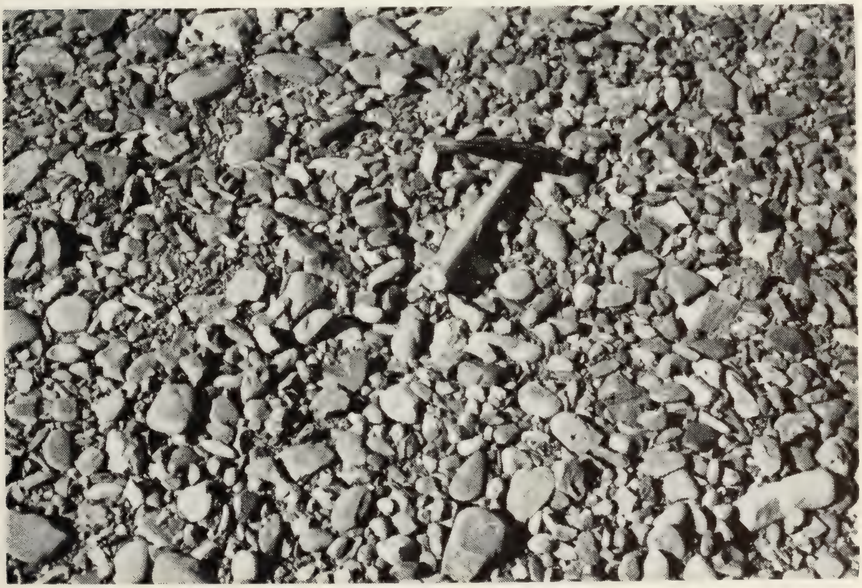


FIGURE 39. Close-up of gravels in stream bed shown in figure 38.

FIGURE 40. State Highway 20 bridge across North Fork of Cache Creek. Bridge was built in 1928 with aggregate from stream bed at site.

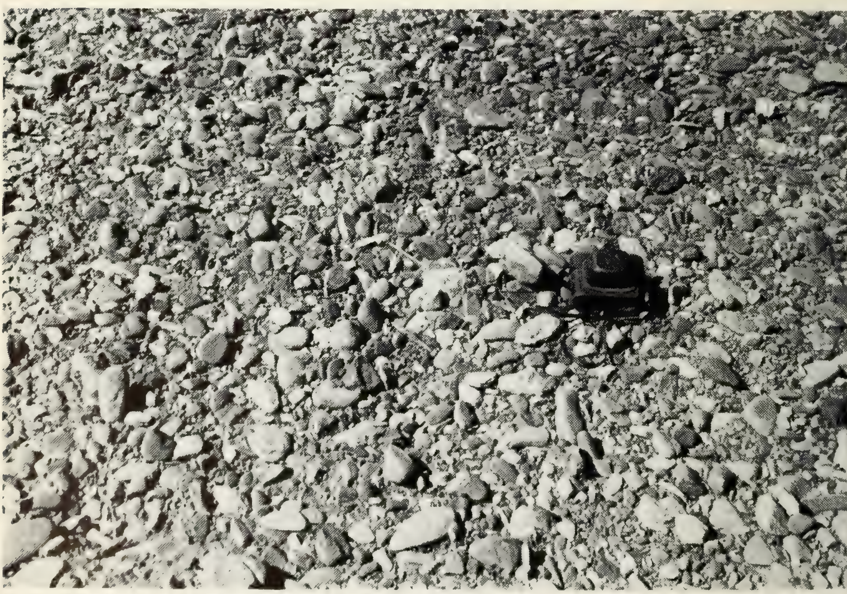


FIGURE 41. Close-up of gravels in stream bed of North Fork Cache Creek near state Highway 20 bridge shown in figure 40.

The aggregates of North Fork Cache Creek are considered to be chemically non-reactive. Chalcedonic chert of the Franciscan group, the only possibly deleterious ingredient, comprises only 1 to 2 percent of the sand and gravel.

Samples from the deposits mentioned above were examined petrographically, using the same techniques as were applied to the Lower Basin deposits. The results of the examination are presented in table 9, *Petrographic Analyses of North Fork Cache Creek Gravel.*

Lithologic Classification. Gravels of North Fork Cache Creek are composed chiefly of Franciscan graywacke-type metasandstone (50 to 60 percent), mildly metamorphosed graywacke crisscrossed with quartz veinlets (10 to 25 percent), metabasic igneous rocks, (greenstone) (6 to 13 percent), quartz veinlets (up to 13 percent), and slaty metasedimentary rocks (2 to 12 percent). The other constituents, none of which exceed 5 percent of the samples, are chert, serpentine, amphibolitic metamorphic rocks, volcanic rocks, limonite, and conglomerate. The percentages of the rock types present in samples from each deposit are presented in table 9. The principal physically unsound rock type is the weathered metasandstone which is crisscrossed by quartz veinlets.

Rock particles of the same types and general proportions as in the associated gravels (described above) compose the bulk of the coarse sand. Quartz largely of the type derived from veinlets in the metasediments of the Franciscan group is more abundant in the sand than in the gravel fraction, the content increasing progressively with decrease in grain size. About one-third of the #28 size is monocrystalline quartz grains in the deposits in the lower reaches of North Fork Cache. Chalcedonic chert is not present in amounts to be a significant possibly chemically reactive ingredient. In accordance with the roundness classification used for gravels, the #8 sand is subangular, #14 and #28 very angular.

Physical Quality (Soundness) Classification. The undeveloped deposits of North Fork Cache Creek classify chiefly in groups C and D as material suitable for the low and medium strength and abrasion resistance requirements of concrete in moderate climate. From these very limited studies it appears that deposits in Indian Valley are of comparatively inferior quality to those downstream, all being classed in group D (usable only if better material is not economically available). About one-third of the pebbles examined in each deposit were of good or satisfactory soundness, 19 to 21 percent were poor, and the remainder were fair. The exact proportions of good and satisfactory, fair, and poor pebbles in the individual deposits are presented in table 9.

Chemical Quality Classification. The only rock type present that is considered potentially chemically reactive is the chalcedonic chert of the Franciscan group. However, the percentage of chert in the $\frac{3}{4}$- to $1\frac{1}{2}$-inch size only ranges up to 3 percent. The deposits are therefore considered to be non-reactive.

Form (Roundness and Flatness) Classification. The pebbles in the deposits of North Fork Cache Creek are predominantly subrounded. Well-rounded pebbles comprise from 2 to 21 percent of the total samples. The samples from Indian Valley contain only 2 to 4 percent well-

rounded pebbles. According to the classification scheme, the aggregates from all the deposits are considered to be subrounded.

The proportion of very flat pebbles in some of the deposits was found to be excessive. One sample from the northern end of Indian Valley and two samples from the stream bed between Long Valley Creek and Chalk Mountain contain over 25 percent very flat pebbles. These aggregates are classed as excessively tabular. The actual percentages of very flat and rounded pebbles in each deposit are presented in table 9.

Quality of Materials as Determined by Routine Laboratory Tests

In 1938, the California Division of Highways tested two samples from the stream bed of North Fork Cache Creek, adjacent to Highway 20 about 3 miles west of the confluence with the main stream. Only a Los Angeles Rattler abrasion test was run. The test results indicated a loss of 24 percent at 500 revolutions.

Economic Possibilities

Volume of Available Material. The roughly estimated quantities of sand and gravel economically available in deposits in the Upper Basin are presented in table 10. These estimates give only the order of size as no drilling or geophysical work was done to determine the depth of the deposits.

Commercial Production. Small amounts of sand and gravel have been produced intermittently from an area adjacent to Highway 20 near the confluence of North Fork and the main stream. There is no large commercial operation; small screening plants with no washing facilities are occasionally operated by one or two men to provide aggregate for use in residential and small building construction in the Clear Lake area.

Non-Commercial Production. In 1928 the California Department of Public Works set up a small screening plant to produce aggregate from the stream bed of North Fork at the site of the bridge which now crosses

Table 10. Rough estimates of volume of sand and gravel available for aggregate in the Upper Basin.

Location	Est. cu. yds.	Overburden	Relation to water table	Gradation	Remarks
North Fork—between points of confluence with main branch and Long Valley Creek; and Cache Creek between North Fork and Wilson Valley	2 million	Little or no stripping	Bulk of materials available above water table during summer and early fall seasons	3″ and 6″ maximum size	Depth of gravel near bridge crossing Highway 20—less than 10 feet
North Fork in Indian Valley south of confluence with Stanton Creek	2 million	Little or no stripping	Materials available above water table during summer and early fall seasons	3″ and 6″ maximum size; progressively finer downstream	Replenished during floods

the stream 2.3 miles west of its confluence with the main branch. The screening plant separated the sand and gravel into two sizes: coarse aggregate of 1½-inch maximum, and fine aggregate, which included everything minus ⅜ inch. The sand and gravel was used as concrete aggregate in the construction of the bridge. To date, the concrete bridge has shown no signs of deterioration.

Marketing. The want of a ready market has accounted for the lack of large-scale commercial development in the Upper Basin. The small market which exists in the residential area on the east side of Clear Lake is supplied by intermittent operations on North Fork about 10 miles east of the lake. The materials are hauled over state Highway 20 which parallels the stream for several miles.

The possibility of marketing aggregate from North Fork in Indian Valley is much more remote as the haulage roads are unpaved county roads over mountainous terrain.

Potential Development. The California State Water Plan (California Dept. Water Resources, 1957) calls for numerous large engineering works in the Upper Basin. Although no concrete dams have been proposed, substantial tonnages of concrete aggregate will be required for spillways, tunnel borings, and other concrete structures. However, although proposed public works would require large tonnages of concrete aggregate, completing these same projects may, in some cases, result in flooding areas of suitable aggregate, eliminating them from future exploitation.

Continued growth in population in the area around Clear Lake and resultant demands for increased amounts of concrete aggregate to build homes and small commercial buildings may lead to the establishment of permanent commercial plants on North Fork Cache Creek adjacent to state Highway 20.

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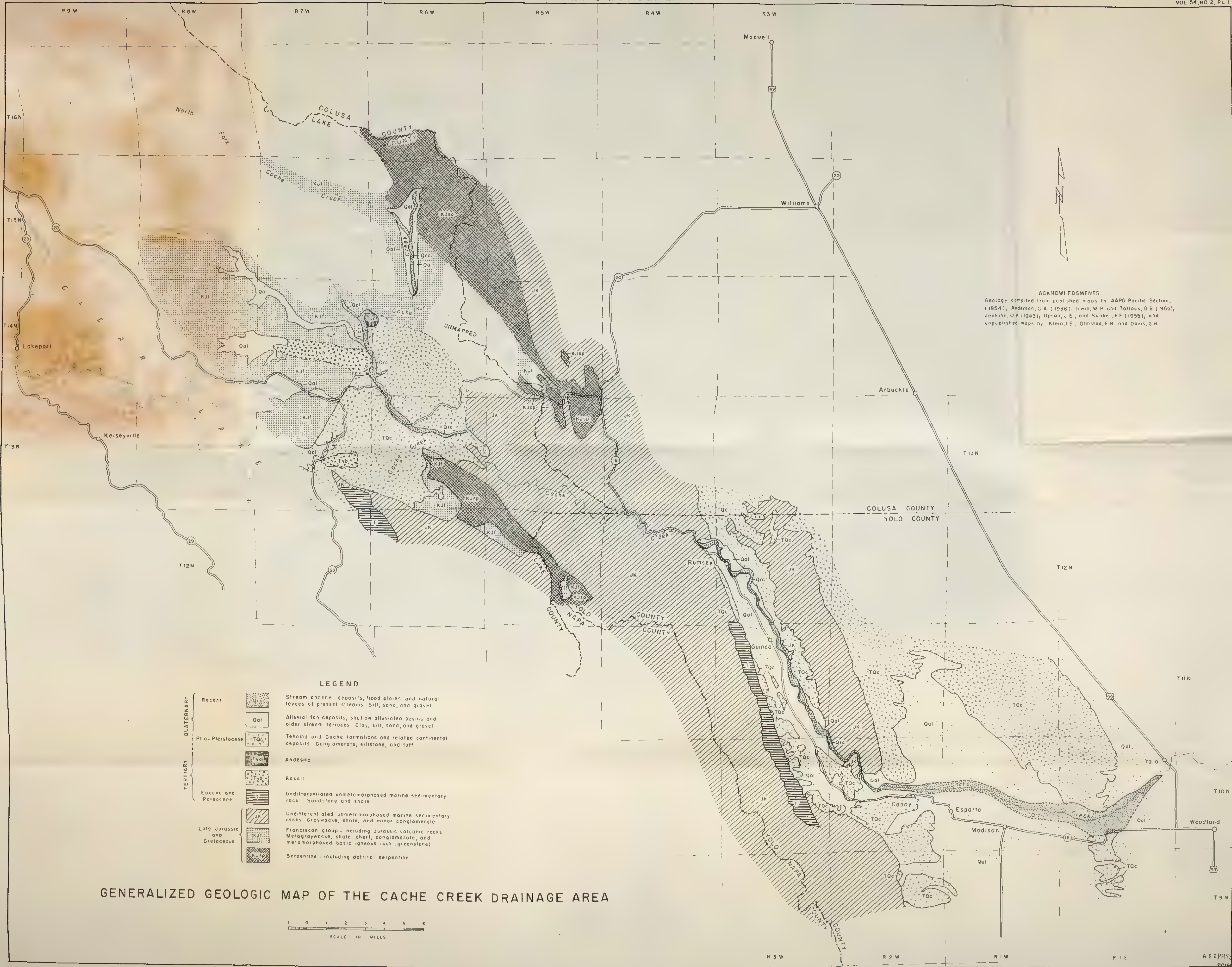
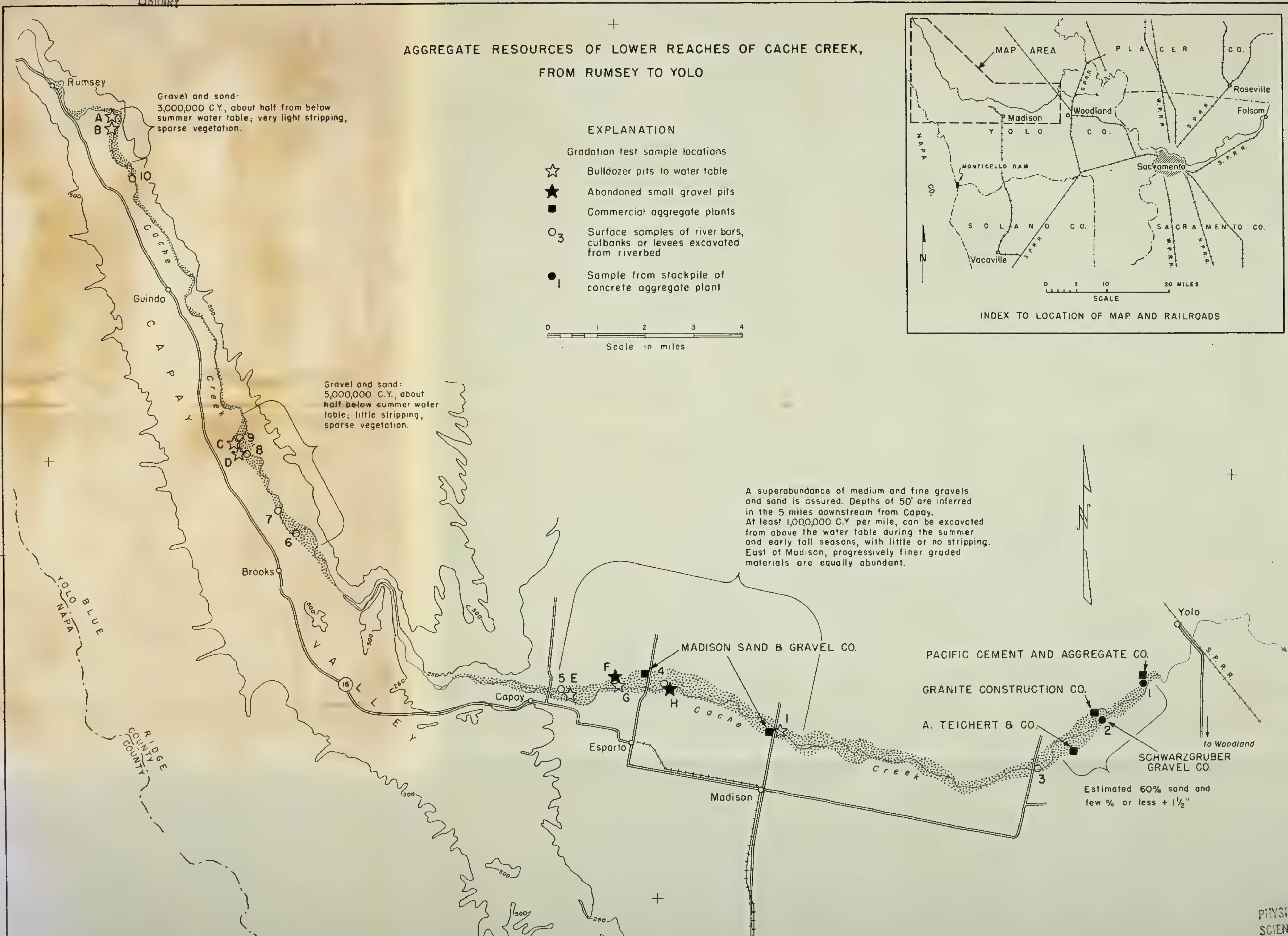
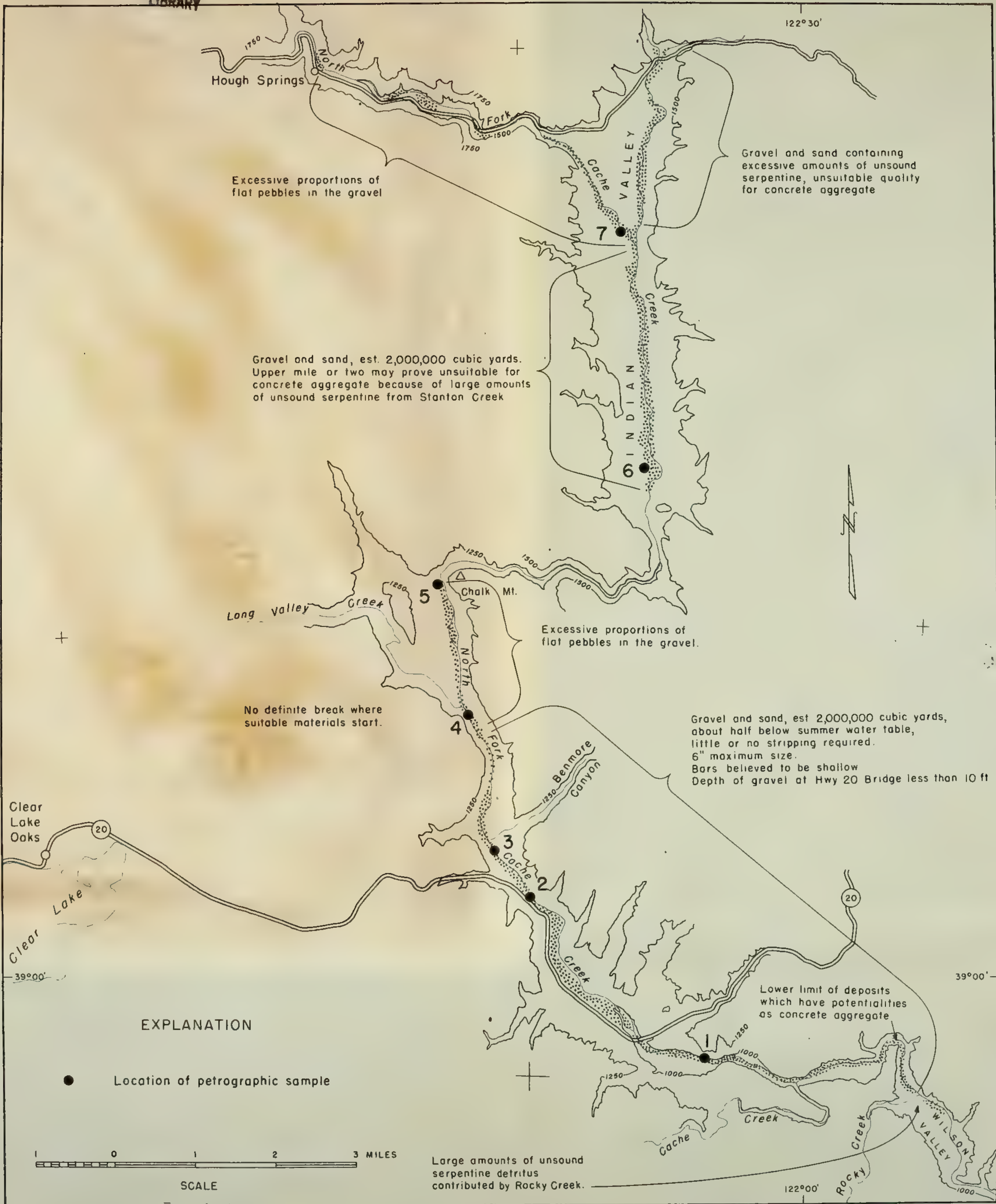
VOL 54, NO 2, PL 1



GENERALIZED GEOLOGIC MAP OF THE CACHE CREEK DRAINAGE AREA


AGGREGATE RESOURCES OF LOWER REACHES OF CACHE CREEK, FROM RUMSEY TO YOLO
EXPLANATION
Gradation test sample locations
Bulldozer pits to water table
Abandoned small gravel pits
Commercial aggregate plants
Surface samples of river bars, cutbanks or levees excavated from riverbed
Sample from stockpile of concrete aggregate plant
Scale in miles
Gravel and sand: 3,000,000 C.Y., about half from below summer water table; very light stripping, sparse vegetation.
Gravel and sand: 5,000,000 C.Y., about half below summer water table; little stripping, sparse vegetation.
A superabundance of medium and fine gravels and sand is assured. Depths of 50' are inferred in the 5 miles downstream from Capay. At least 1,000,000 C.Y. per mile, can be excavated from above the water table during the summer and early fall seasons, with little or no stripping. East of Madison, progressively finer graded materials are equally abundant.
Estimated 60% sand and few % or less + 1½"
Rumsey
Guinda
Brooks
Capay
Esparto
Madison
Yolo
to Woodland
CAPAY VALLEY
Cache Creek
YOLO BLUE RIDGE
NAPA COUNTY
MADISON SAND & GRAVEL CO.
PACIFIC CEMENT AND AGGREGATE CO.
GRANITE CONSTRUCTION CO.
A. TEICHERT & CO.
SCHWARZGRUBER GRAVEL CO.
S.P.R.R.
38°45'
122°00'
INDEX TO LOCATION OF MAP AND RAILROADS
MAP AREA
PLACER CO.
YOLO CO.
NAPA CO.
SOLANO CO.
SACRAMENTO CO.
Madison
Woodland
Roseville
Folsom
Sacramento
MONTICELLO DAM
Vacaville
SCALE
20 MILES



AGGREGATE RESOURCES OF NORTH FORK CACHE CREEK AND CACHE CREEK ABOVE WILSON VALLEY

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

CALIFORNIA JOURNAL OF MINES AND GEOLOGY

Volume 54, Number 3
July 1958

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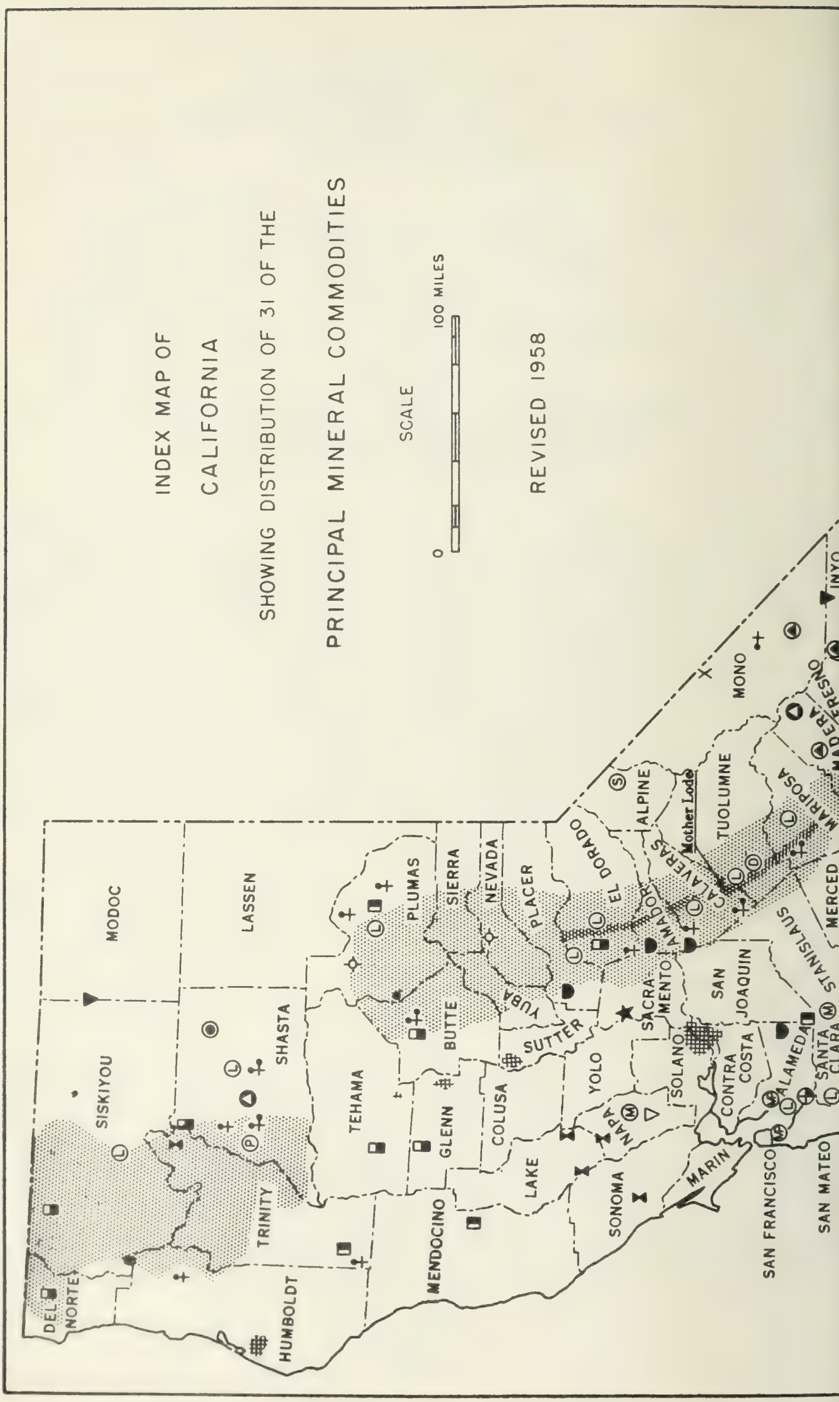
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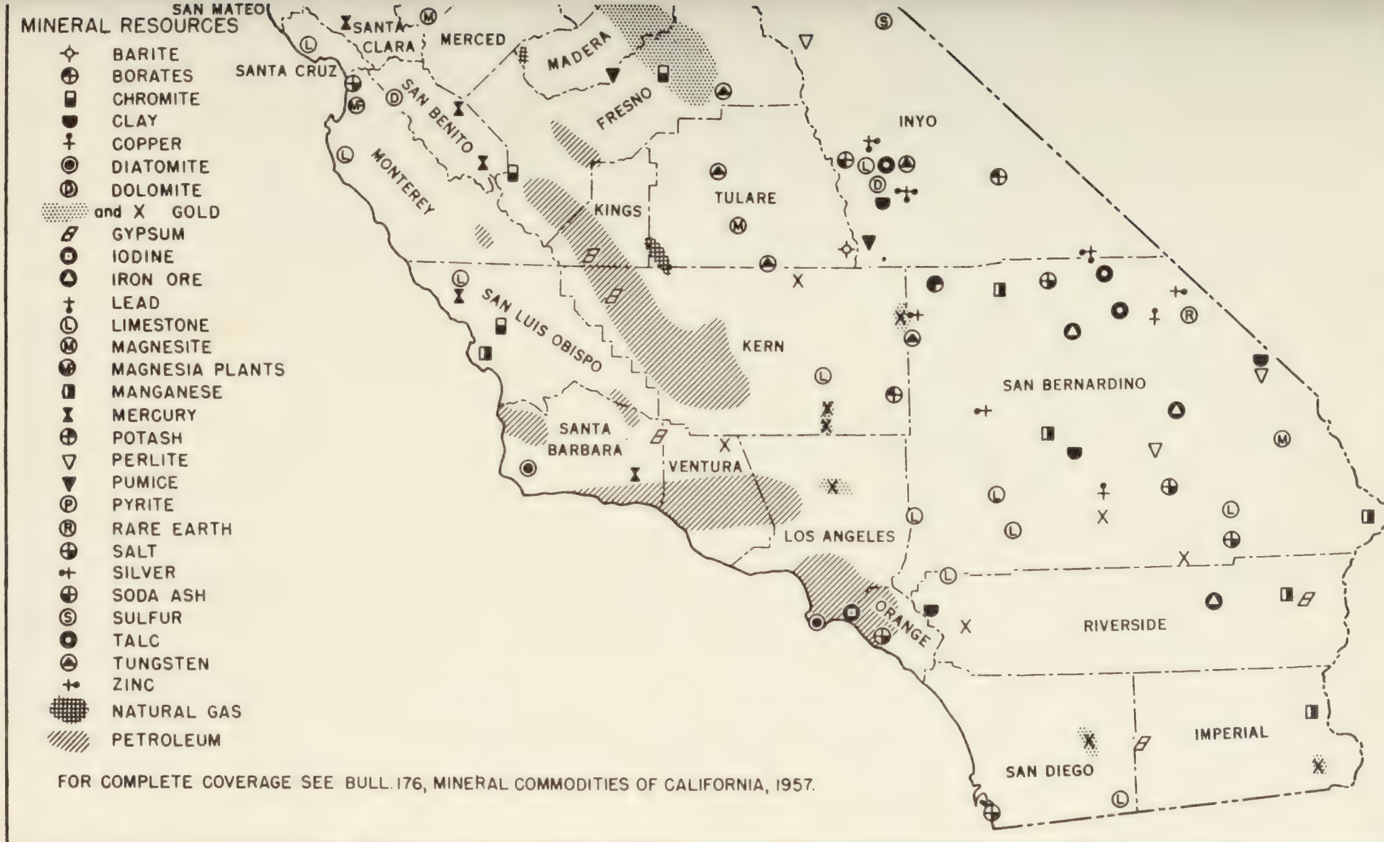
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
MENDOCINO
GLENN
BUTTE
SIERRA
NEVADA
COLUSA
YUBA
PLACER
LAKE
SUTTER
YOLO
EL DORADO
SONOMA
NAPA
SACRAMENTO
AMADOR
ALPINE
MARIN
SOLANO
SAN JOAQUIN
CALAVERAS
Mother Lode
TUOLUMNE
MONO
SAN FRANCISCO
CONTRA COSTA
STANISLAUS
MARIPOSA
SAN MATEO
ALAMEDA
SANTA CLARA
MERCED
MADERA
FRESNO
INYO


MINERAL RESOURCES
BARITE
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CLAY
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and X GOLD
GYPSUM
IODINE
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LEAD
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MAGNESITE
MAGNESIA PLANTS
MANGANESE
MERCURY
POTASH
PERLITE
PUMICE
PYRITE
RARE EARTH
SALT
SILVER
SODA ASH
SULFUR
TALC
TUNGSTEN
ZINC
NATURAL GAS
PETROLEUM
SAN MATEO
SANTA CLARA
SANTA CRUZ
MERCED
MADERA
FRESNO
SAN BENITO
MONTEREY
KINGS
TULARE
INYO
SAN LUIS OBISPO
KERN
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL
FOR COMPLETE COVERAGE SEE BULL. 176, MINERAL COMMODITIES OF CALIFORNIA, 1957.

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Plate

POVERTY HILLS DIATOMACEOUS EARTH DEPOSIT INYO COUNTY, CALIFORNIA

By George B. Cleveland *

OUTLINE OF REPORT

Illustrations

ABSTRACT

A deposit of diatomaceous earth exposed in a small area on the east slope of the Poverty Hills, Inyo County, California, is part of a lacustrine formation that is probably Pleistocene in age. The lake beds rest on crystalline bedrock and are overlain by basalt, younger lake beds, and alluvium. A 4-foot bed of diatomaceous earth, exposed for a lateral distance of about 1,750 feet, forms part of a west-tilted fault block. The diatomaceous earth is nearly pure; *Epithemia* and *Fragilaria* are the most abundant diatom genera in it.

Economically mineable reserves of diatomaceous earth are estimated at about 2,500 tons. The deposit has yielded about 600 tons since 1947, and this was used in high-temperature insulating cement.

GEOLOGIC SETTING

In California, deposits of fresh-water diatomaceous earth are widespread but have had little commercial development. They are locally present in the Pleistocene (?) lake beds of the Owens Valley region in the east-central part of the state—in the Poverty Hills, on the northwest side of Long Valley, and on Paoha Island in Mono Lake.

Freshwater diatomaceous earth is less well known in California than the extensive marine deposits. In the coastal regions of southern California, the marine Miocene Monterey and Pliocene (?) Sisquoc formations and their equivalents have yielded nearly 3 million tons of diatomaceous earth. The deposits at Lompoc, Santa Barbara County, are among the largest in the world. Although diatomaceous earth of freshwater origin is being brought into the state from Oregon and Nevada, little has been produced in California in recent years.

* Mining geologist, California Division of Mines, Los Angeles.

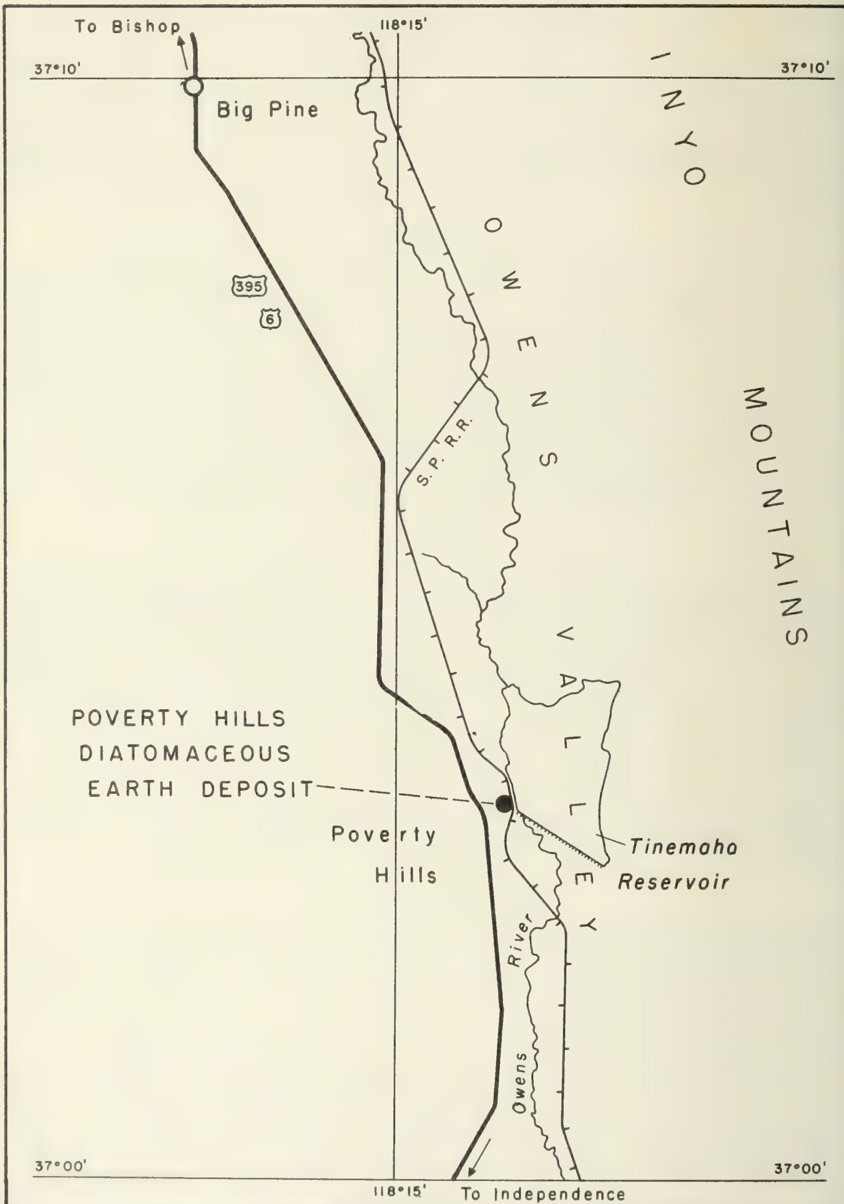

FIGURE 1. Index map showing location of Poverty Hills diatomaceous earth deposit.

The diatomaceous earth deposit in the Poverty Hills is in sections 23 and 26, T. 10 S., R. 34 E., M.D., along combined Highways 395 and 6, 245 miles north of Los Angeles and 8 miles south of Big Pine, Inyo County.

Owens Valley, which extends from the Mono Lake region southward for over 100 miles to Indian Wells Valley near the northern part of the Mojave Desert, lies between the Sierra Nevada on the west and the White and Inyo Mountains on the east. Owens Lake, which is now nearly dry, lies near the southern end of the valley. From Owens Lake northward the floor of Owens Valley becomes progressively narrower, reaching a minimum width of 1 mile just south of the Poverty Hills. North of the hills, the valley floor widens again; and in the vicinity of Bishop, 20 miles to the north, it is several miles across. The northern part of the valley is nearly flat, rising only about 200 feet between the Poverty Hills and Bishop. In Pleistocene to Recent time it was occupied at two or more times by a freshwater lake. The Poverty Hills trend northward, forming a bold topographic feature that rises 1,000 feet above the broad alluvial apron that separates them from the Sierra Nevada front 5 miles to the west. On the east, the Poverty Hills border the western shore of Tinemaha Reservoir in which Owens River water for the Los Angeles aqueduct system is stored.

The hills are composed of granitic and metamorphic rocks and are somewhat less rugged than the volcanic cones that border the Sierra Nevada front to the north and south. The diatomaceous earth deposit is exposed at an elevation of 4,000 feet on a low elongate hill immediately east of the main part of the Poverty Hills. Highways 395 and 6 skirt the east side of the Poverty Hills proper and pass west of the small hill.

Moderate to cold winters prevail in this part of Owens Valley, and a sparse annual rainfall of about 4 inches supports only low brush and grass. The small reddish plant of the buckwheat family, *Eriogonum* sp., commonly grows on fine-grained sediments in this region; in the vicinity of the deposit it appears to be confined exclusively to the diatomaceous sedimentary rocks.

Knopf (1918, p. 49) in a geological reconnaissance of the Sierra Nevada and Inyo Ranges briefly described this deposit and presented a list of diatoms identified by Albert Mann. Bateman's (1954) geologic study of the eastern front of the Sierra Nevada has shown the age and general distribution of the rocks in the vicinity of the Poverty Hills deposit.

The Poverty Hills diatomaceous earth deposit is one of several similar accumulations that occur in basins along the Owens Valley trough. These deposits are genetically related in that they were formed in freshwater lakes which occupied local basins in Owens Valley. The basins were connected by streams that drained southward from ancient Lake Russell, now called Mono Lake, through the Owens Valley and ultimately to ancient Lake Manly in Death Valley (Blackwelder, 1954, p. 35; W. C. Putnam, personal communication, 1957).

In the Poverty Hills, the diatomaceous earth is intercalated with other lacustrine sediments of probable Pleistocene age. These beds are on the southwest slope of the low hill, and rest upon quartz monzonite of Middle Cretaceous (?) age (Bateman, 1954). Although poorly exposed, they appear to have a minimum thickness of 300 feet and extend

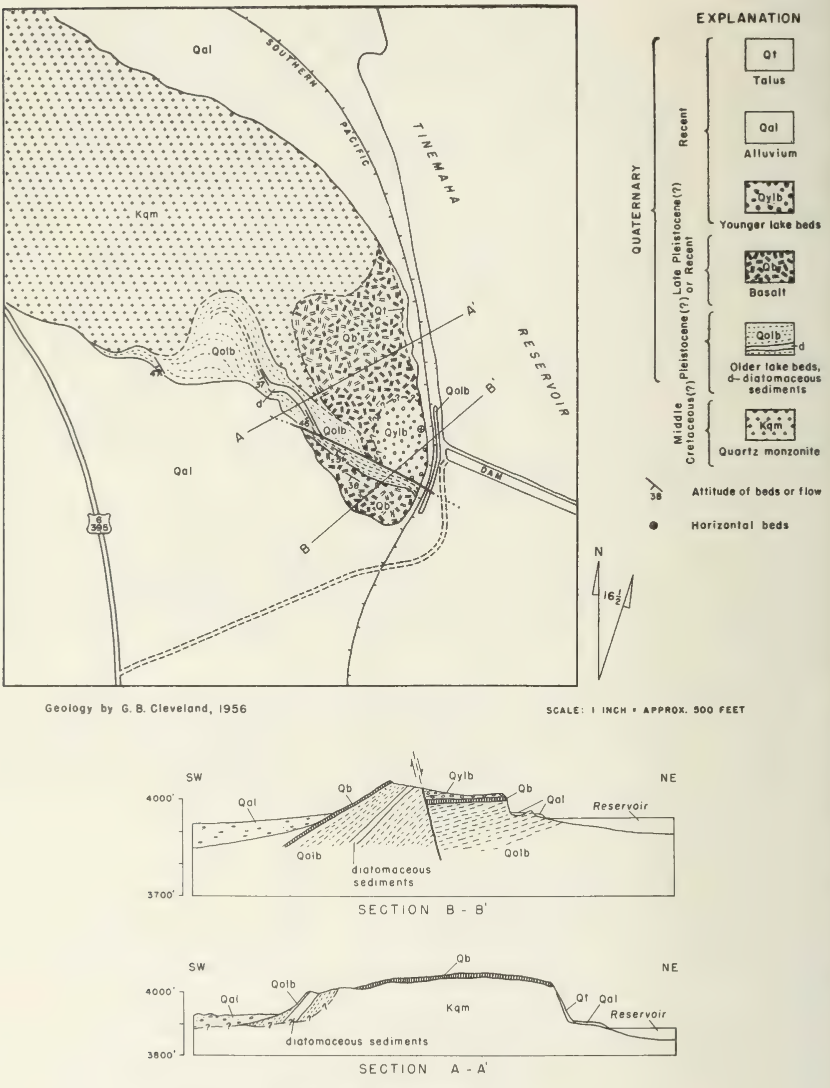

FIGURE 2. Geologic sketch map and cross sections of Poverty Hills diatomaceous earth deposit.

for a distance of about 2,000 feet along the flank of the hill. They are composed of greenish-gray, brown, and reddish-brown sandstone, greenish-gray and brown diatomaceous siltstone and shale, and white diatomaceous earth. In the vicinity of the pits, where the diatomaceous earth has been mined, the beds strike N. 30° W. and dip about 46° SW. Near their southernmost exposure the strike is N. 55° W. and the dip 51° SW. In their more westerly exposures, the lacustrine beds form a near dip slope, and to the east and south they are unconformably overlain by an olivine basalt flow about 3 feet thick. This flow strikes N. 55° W. and dips 38° SW. where it overlies the lacustrine beds on the south; on the east it is nearly flat-lying. The diatomaceous earth is in three or more layers. The thickest of the known layers is near the top of the lacustrine unit, separated from other less pure layers by tuffaceous shale and siltstone. As it is less resistant than the enclosing strata it forms a shallow depression along the strike. Where the main bed is exposed it is uniformly about 4 feet thick; but the other beds are apparently less than 2 feet thick. Overlying the basalt, east of the diatomaceous earth deposit, is a poorly exposed 6-foot bed of greenish-gray pebble conglomerate. This stratum is nearly flat-lying and is composed principally of granitic rock cemented by a matrix of limy coarse-grained sandstone. Recent alluvium mantles all rock units below an elevation of 3,920 feet, and thin talus covers a portion of the steep slope above the railroad cut northeast of the deposit.

Near the southern part of the mapped area, a normal fault cuts the lake beds and the overlying basalt. This fault trends about N. 65° W. and dips about 80° NE. It has a minimum vertical displacement of about 125 feet with the downthrown side on the northeast. This fault can be traced northwestward beyond the Poverty Hills, to where it extends beneath the volcanic flows of Crater Mountain. To the southeast of the diatomite deposit the fault extends across the Owens Valley and beneath another large flow and reappears on the west flank of the Inyo Mountains (C. A. Nelson, personal communication, 1957). The steep dip of the older lacustrine sediments suggests that a normal fault of large displacement may lie to the east of the Poverty Hills. Knopf (1918, p. 50) states that these beds have a greater dip than do the other late Cenozoic lake beds in this region.

Northeast of the Poverty Hills a section of lake beds is exposed along the western front of the Inyo Mountains east of Big Pine. These beds have been tilted by faulting so that now they are exposed from 50 to over 1,200 feet above the valley floor (Walcott, 1897; and Knopf, 1918). They were laid down in a body of water named Lake Waucobi by Walcott. Lithologically these elevated beds show little similarity to the lacustrine sediments exposed in the Poverty Hills.

DIATOMACEOUS EARTH

Diatoms are found in oceans, lakes, streams, and in most other moist environments. Under favorable conditions, they occur in large numbers and form the basic food supply for larger aquatic organisms. Concentrations of over 500,000 individuals per liter have been recorded from waters off southern Mexico (Allen, 1939, p. 181). Diatoms are holophytic in that they utilize photosynthesis in their life process. However,

FIGURE 3. White diatomaceous earth cropping out of lake-bed sequence below basalt flow. Lava flows in background may have dammed Owens River in Recent time. View south.

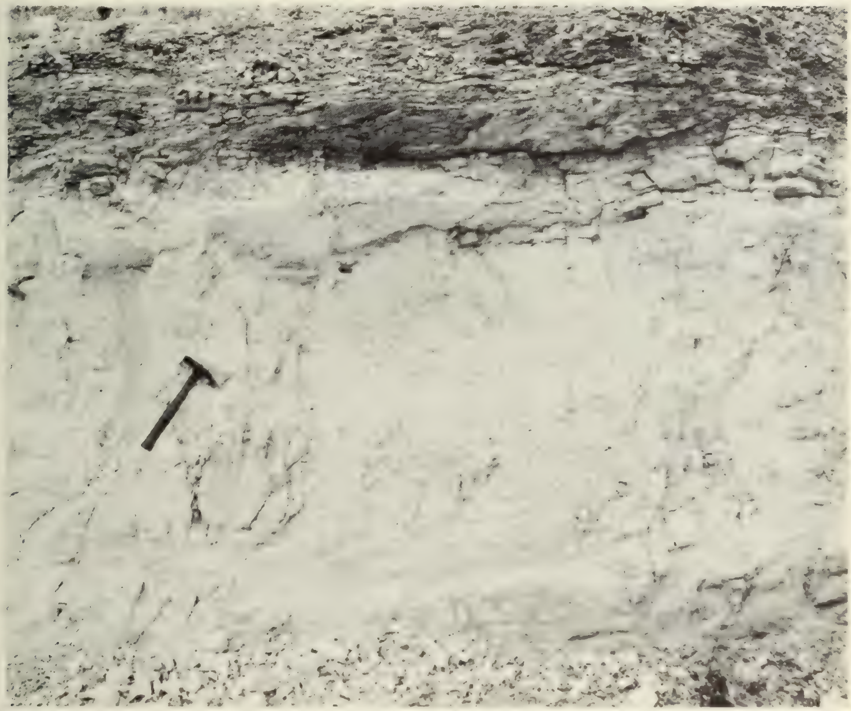

FIGURE 4. Principal diatomaceous earth bed overlain by thin-bedded diatomaceous shale.

they produce a fatty oil instead of the carbohydrates produced by green terrestrial plants. Most species are floating forms (plankton) living at the surface of the water or within the depth to which sunlight can penetrate. After death they slowly settle to the floor of the ocean or lake. If they are abundant enough they form oozes that may later become consolidated beds of diatomaceous earth.

Diatoms require well-lighted water containing dissolved nitrogen, phosphorus, potassium, sodium, magnesium, oxygen, hydrogen, carbon, sulfur, iron, and silica. The concentration of dissolved nitrogen (as NH_3 and NO_3) and phosphorus (as PO_4) is generally considered a limiting factor in diatom growth because of the relative paucity of these compounds in lake and ocean waters. Silica is more abundant than either nitrogen or phosphorus in such waters and the size of the diatom population is ordinarily directly proportional to the concentration of dissolved or finely divided silica. Silica is utilized by the diatom in building its frustule and may well be necessary for normal nutrition (Cupp, 1943, p. 26).

Taliaferro (1933) and others have demonstrated the common association of diatomaceous earth with volcanic ash. This relationship is attributed to the freeing of silica as a principal product in the chemical alteration of volcanic ash. However, silica can also be supplied from finely divided rock material and silica-rich volcanic solutions. Conger (1942, p. 58) has pointed out that a concentration of 1 ppm of silica

FIGURE 5. Main pit in Poverty Hills deposit, showing color change between white upper and pale-gray lower half of diatomaceous earth bed. View northwest.

is sufficient for diatom growth and that 5 to 20 ppm will produce an abundant flora. Cold, neutral to slightly alkaline waters also tend to favor diatom production. These conditions are interrelated in that cold water inhibits the growth of bacteria and thus reduces the formation of acids attending decomposition processes. Cold water also contains greater amounts of dissolved carbon dioxide and oxygen (Conger, 1942, p. 56-57).

The diatomaceous earth in the Poverty Hills deposit is a massive, compact rock that fractures into angular fragments. On fresh surfaces it is faintly gray in color at the base, and nearly white in the upper half of the bed. Weathered exposures are light buff. The material is relatively hard and light in weight. A typical sample had an apparent specific gravity of 0.58 and a pH of 7.7. Microscopic examination showed only a small percentage of non-gritty impurities composed principally of volcanic ash, biotite, manganese oxide and carbonaceous matter. A partial chemical analysis is given in table 1.

The diatom assemblage is composed almost entirely of elongate forms typical of freshwater deposits. The most common forms are the arcuate types of the genera *Epithemia* and *Cymbella,* and the colonial forms of the genus *Fragilaria*. The dominant genus differs from place to place in the deposit. A few freshwater sponge spicules have been found with the diatoms. A list of the diatoms present in the deposit is given in table 2.

Table 1: Chemical analyses of California diatomaceous earths.

	1.	2.	3.	4.
SiO_2	79.20	90.25	88.68	86.89
Al_2O_3	—	1.55	2.68	2.32
Fe_2O_3	—	0.65	Trace	1.28
MnO	0.009	—	—	—
MgO	0.51	—	1.30	Trace
K_2O	—	—	—	3.58
CaO	1.01	0.25	1.61	0.43
Ignition loss	—	—	5.54	4.89

1. Poverty Hills deposit, Inyo County. Analysis by George W. Gooch Laboratories, Los Angeles. Courtesy of Norval F. Hazen.
2. Pit River deposit, Shasta County. Analyses by Smith-Emery Company, San Francisco (Logan, 1926, p. 166).
3. Lompoc area, Santa Barbara County (Eardley-Wilmot, 1928, p. 5).
4. Monterey County (Eardley-Wilmot, 1928, p. 5).

NOTE: Samples 1 and 2 are from freshwater deposits. Dashes indicate no analyses made for oxides.

South of the deposit two basalt flows, which originated from cones on either side of the valley, lie within half a mile of each other near the center of the valley. These flows appear to have coalesced; but their junction, if existent, is now covered by Recent river sediments. Although these flows are younger than the older lake beds, they may have formed a dam north of which the younger lake beds were deposited. A similar dam may have existed during an earlier period. Recurring movement on the normal fault which bisects the area may have produced a dam across the Owens River and caused both periods of sedimentation.

The lake in which the Poverty Hills sediments accumulated apparently covered an area of at least 150 square miles and extended from the Poverty Hills northward several miles beyond Bishop. The dominance of the diatom genera *Epithemia* and *Cymbella*, and the species *Fragilaria construens*, which are all shallow water forms, suggests that the lake was relatively shallow (Conger, 1942, p. 63; Hutchinson, et al., 1956, p. 1501).

At least 260 feet of coarse clastic sediments were deposited before the fine-grained volcanic sediments entered the lake. Only after the ash was introduced did suitable conditions develop for the growth of large numbers of diatoms. After the initial deposition of volcanic ash, a period of volcanic quiescence allowed the diatoms to flourish in relatively clear water and to form a nearly uncontaminated deposit before the deposition of ash resumed. That a gradual change from poor to favorable growing conditions took place is shown by the gradition from diatoma-

Table 2. Diatoms in the Poverty Hills deposit.[1]

Epithemia argus (Ehrenberg) Kutzing	Very common
Fragilaria construens Ehrenberg (numerous varieties)	Very common
Cymbella gastroides Kutzing, especially variety *minor* Grunow	Common
Melosira crenulata Kutzing, principally varieties *laevis* and *semilaevis* Grunow	Common
Gomphonema constrictum Ehrenberg, variety *capitata*	Common
Synedra capitata Ehrenberg	Frequent
Epithemia (Rhopalodia) gibba (Ehrenberg) Kutzing, variety *ventricosa* Grunow	Rare
Cocconeis placentula Ehrenberg	Rare

[1] From Knopf, 1918, p. 50.

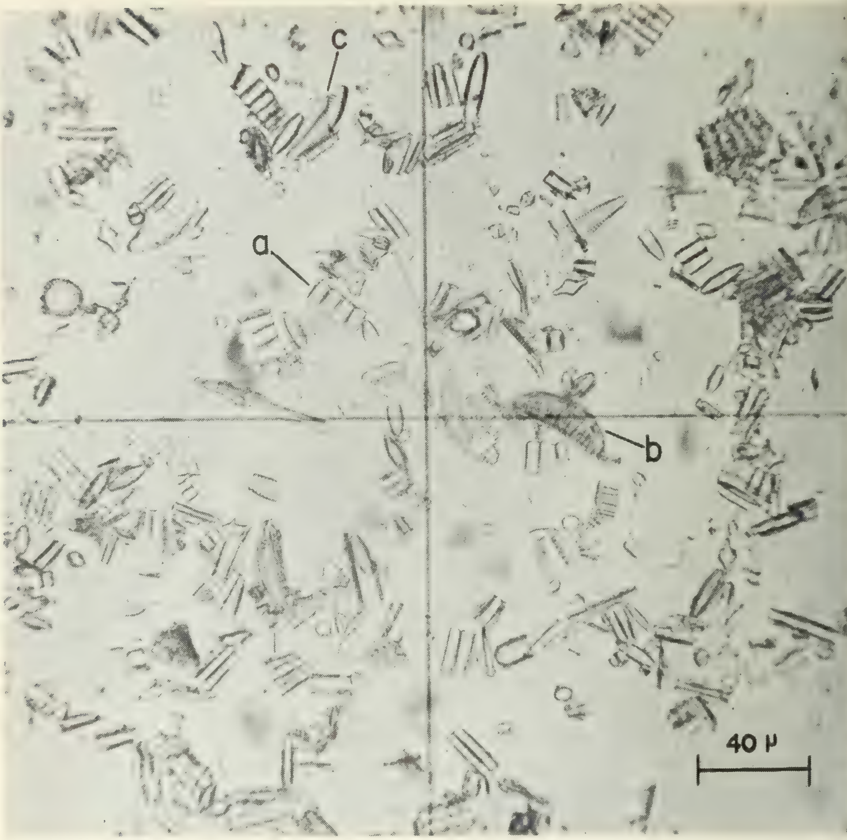

FIGURE 6. Photomicrograph of diatoms from the Poverty Hills deposit. a, *Fragilaria;* b, *Epithemia;* c, *Cymbella.*

ceous tuff to a 4-foot bed of nearly pure diatomaceous earth. Then, near the top of the section, there is a less gradual change back to dominantly tuffaceous rock.

The ash was probably the principal source of silica as there was no silicification of the rocks or other evidence to suggest that volcanic solutions provided any of the silica. As glacial sediments are not associated with the diatomaceous earth, rock flour probably was not an important source. Furthermore, in the volcanic sediments diatom frustules were observed in the tubes or adhering to the surface of pumice fragments. Some individuals are distorted so that their shapes conform to that of the enclosing tube. This may indicate the dependence of diatoms on the ash as a source of silica or it may be a fortuitous entrapment of the individuals during normal sedimentation. The cold climate that persisted during much of the Pleistocene may have effectively increased the amount of oxygen and carbon dioxide dissolved in the water and prevented the formation of organic acids that would have inhibited diatom growth. The supply of nutrients may also have been augmented by nitrogen, sulfur, carbon dioxide, and other elements and compounds associated with the volcanic activity.

PENNSYLVANIA (TINEMAHA) CLAIMS[1]

Recent production of diatomaceous earth from the Poverty Hills deposit began in 1947 and continued intermittently until 1954 when milling facilities at Big Pine were destroyed by fire. The property had been discovered and some development work done prior to 1913, when Knopf (1918) visited the deposit. In 1946 N. F. Hazen of Puente, California, located three mining claims, the Pennsylvania Numbers 1, 2, and 3. The deposit is said to have yielded about 600 tons of diamaceous earth since 1947, valued at about 4 dollars per ton at the mine.

Diatomaceous earth was mined from a 4-foot bed in a less pure zone 35 to 40 feet thick. The material was taken from two open cuts along the strike, the larger of which was about 130 feet long and 15 feet wide. In this cut the diatomaceous earth is overlain by 2 feet of diatomaceous shale which was stripped off prior to mining. The commercial material was drilled and blasted and moved to trucks by bulldozers at the cost of about 2 dollars per ton. The crude diatomaceous earth was transported by truck to Big Pine, about 8 miles north of the mine, where it was reduced to minus 100 mesh in a Raymond mill, air classified, packaged in 50 pound bags, and shipped to Los Angeles. Material after processing was valued at 16 to 28 dollars per ton. This earth has been used as a constituent in high-temperature insulating cement (700° to 2,000° F). The cement is composed essentially of rock wool, a portion of which is asbestos; the diatomaceous earth acts as a binder. The material could also be used as insecticide carrier, filler, and as an aggregate in cement. The principal deterrent to future production is said to be lack of nearby milling facilities and insufficient storage area for an intermittent operation (N. F. Hazen, personal communication, 1956).

Economic recovery of the diatomaceous earth is limited to a narrow area along the strike where the basalt flow has not been preserved. Removal of this flow to gain access to the underlying earth in other parts of the deposit would not be economically feasible. The recoverable portion of the diatomaceous earth bed lies directly north of the normal fault that bisects the area. The northern limit of recovery is where the diatomaceous earth bed butts against the basement rocks. The diatomaceous earth can be economically mined down the dip slope from the present workings to the intersection of the lake bed sequence with the alluvium; further development would necessitate removal of excessive overburden. Minimum reserves of economically mineable material, lying below an overburden that ranges from about 2 to 15 feet, are estimated at 200,000 cubic feet, weighing 25 pounds per cubic foot, or a total of about 2,500 short tons. This estimate is based on an apparent density of 0.4 for solid dry diatomaceous earth, and the continuity at depth of the observed dimensions of the diatomite bed at the surface. However, the configuration of the bedrock at depth could materially reduce this estimate.

Although the estimated reserves of the Poverty Hills deposit are not large they may represent only a small part of a layer that underlies an area of many tens of square miles. Inasmuch as the deposit crops out on what appears to be the periphery of a large basin there is some justification for expecting the layer to become thicker near the center

[1] Mr. N. F. Hazen kindly supplied part of the information on the Pennsylvania claims.

of the basin. However, near the center a correspondingly thicker overburden would also be present. Both of these thicknesses therefore, would have to be known and the value of the diatomaceous earth determined, before the feasibility of mining this material over a wider area could be determined.

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MINES AND MINERAL RESOURCES OF TULARE COUNTY, CALIFORNIA

By J. Grant Goodwin *

OUTLINE OF REPORT

Illustrations

* Mining Geologist, California Division of Mines. Manuscript submitted for publication December 1957.

PHOTO 1. The High Sierra from Kings Canyon Overlook, Sequoia National Park. *Photo by Mary Hill.*

ABSTRACT

Tulare County, with an area of 4,935 square miles, is divided into two geomorphic provinces. The valley portion, underlain by Tertiary and Quaternary sedimentary rocks and Recent alluvium, has been a source of sand, gravel, clay, oil, and gas; the valley supports a rich agricultural industry, and holds the bulk of Tulare County's 148,600

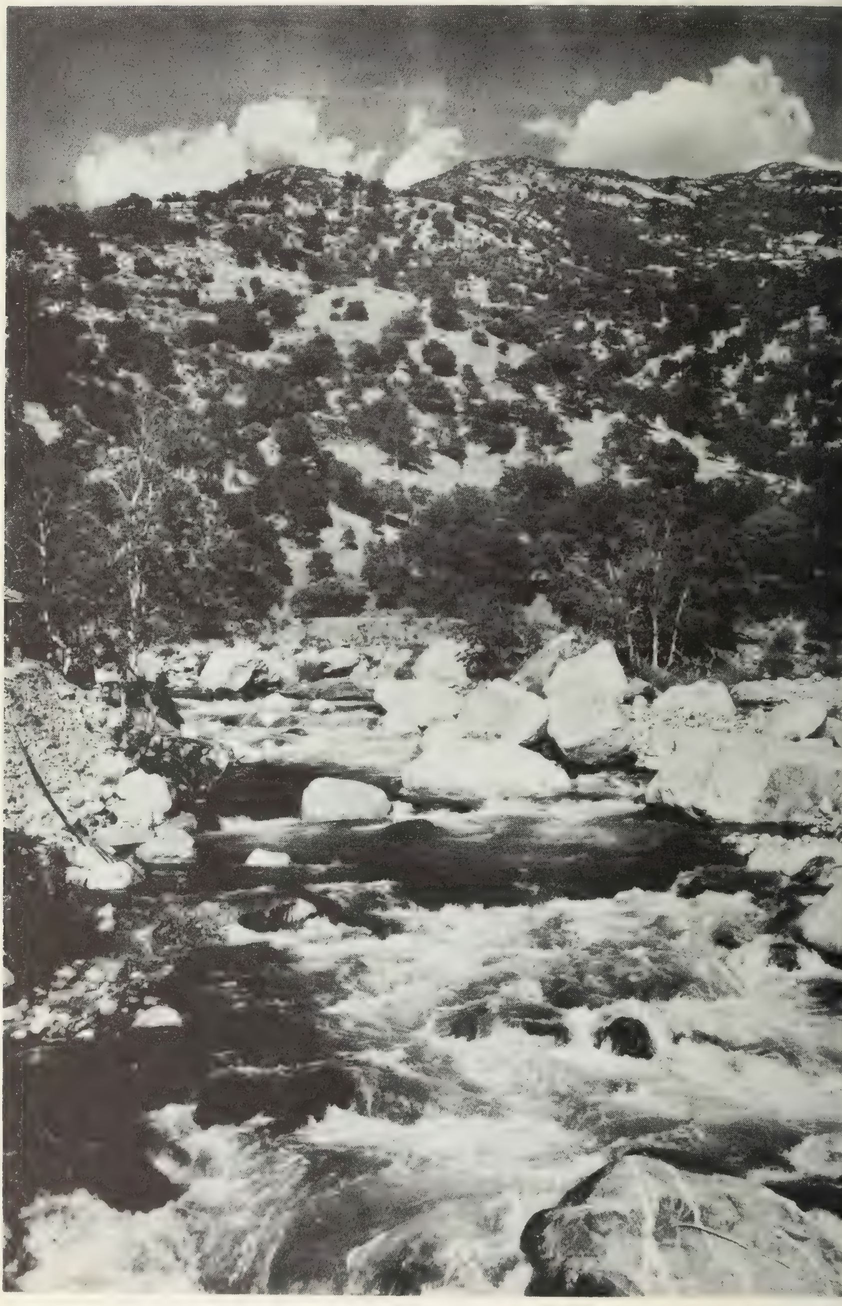

PHOTO 2. East Fork of Kaweah River north of Three Rivers. The Kaweah River and its several forks drain much of the Tulare County portion of the west face of the Sierra Nevada. *Photo by Mary Hill.*

inhabitants. The mountainous portion of the county, which constitutes about 65 percent of the total area, is virtually undeveloped. A large portion of the Sierra Nevada province is underlain by granitic rocks with included pendants of metamorphic rocks. Along the foothills, dividing the two provinces, lies a belt of metamorphosed basic intrusive rocks, metavolcanic rocks, and interbedded metasedimentary rocks. The Sierran intrusive bodies and included pendants of metamorphic rocks have been a source of tungsten, feldspar, limestone, granite building stone, and some base metals, gold, and silver. The metamorphic belt along the Sierran foothills has yielded magnesite, chromite, manganese, and gem chrysoprase, and contains lateritic nickel and nickel-bearing magnesite of unknown potential.

The total mineral production of Tulare County from 1880 through 1955 has been $31,445,159. The leading mineral products in order of importance are natural gas, sand and gravel, and tungsten. Recent mineral production has been restricted to these three commodities and some petroleum.

INTRODUCTION

Geography and Culture. Tulare County is known principally as a source of agricultural products. A total of 1,037,400 acres is under cultivation. The total assessed valuation in 1951-52 was $177,128,028. Water for irrigation is supplied through a series of canals from the Kaweah and Tule Rivers and by the Central Valley Project. The chief agricultural products are oranges, grapes, hay, cotton, olives, raisins, and beef cattle. The cultivated land and centers of population are found only in the extreme western third of the county, in the San Joaquin Valley. The Sierra Nevada foothills are useful largely as grazing land, and the eastern two-thirds of the county is mountainous and undeveloped.

The annual rainfall in the populated areas is 8 to 10 inches. Rain falls only during the winter months, during which time the eastern portion of the county is blanketed with snow. The average minimum and maximum temperatures in the valley portion of the county are 60 to 90 degrees in summer and 30 to 60 degrees in winter.

Tulare County is traversed from north to south along the western boundary by the Santa Fe and Southern Pacific railroads, and by U. S. Highway 99. The populated valley areas are well traversed and interconnected by a system of paved county roads. Access to the mountainous regions is extremely limited.

Tulare County is bounded on the west by Kings County in the San Joaquin Valley, on the north by Fresno County, on the south by Kern County, and on the east by Inyo County. The eastern boundary lies along the crest of the Sierra Nevada and passes through a chain of the highest peaks in the United States. Mount Whitney, the highest, has an elevation of 14,496 feet. National parks, and other reserves in Tulare County, include Sequoia National Park, General Grant Grove, Kings Canyon National Park, and the Tule Indian Reservation.

Geologic History and Geomorphology. The geology of Tulare County is not known in detail, and geologic mapping, even on a reconnaissance scale, is limited. Tulare County occupies a portion of the Sierran fault block which was elevated and tilted westward during Pleistocene time.

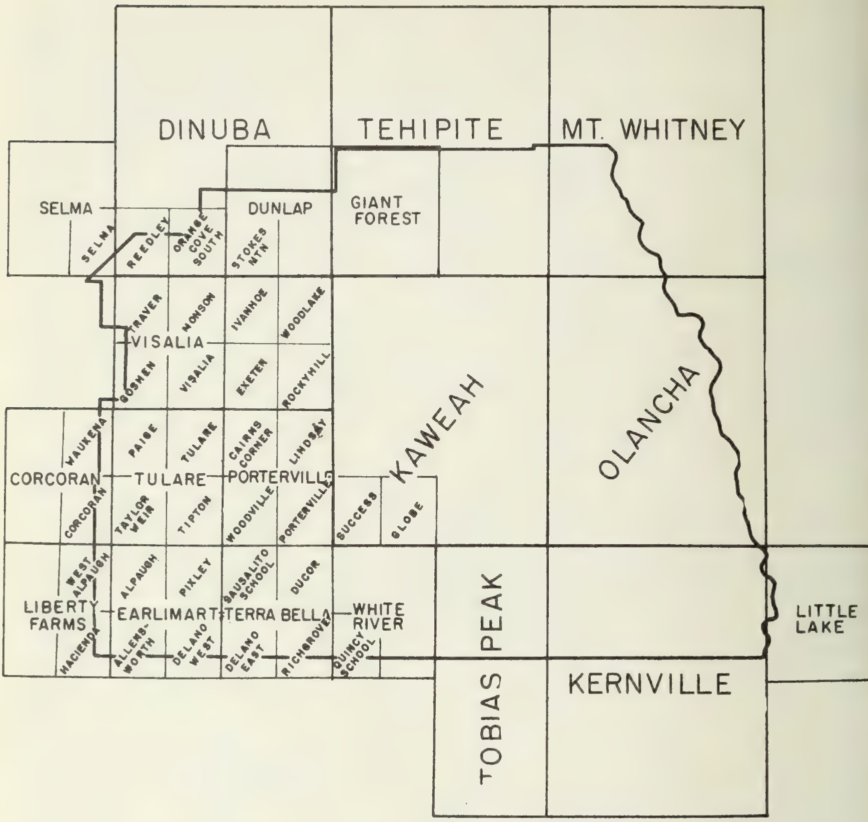

FIGURE 1. Index to topographic mapping, Tulare County.

Subsequent glaciation and stream erosion have carved the present landscape. The western portion of Tulare County is covered by Quaternary and Recent alluvium eroded from the uplifted Sierra Nevada block.

The oldest known rocks in Tulare County are the pendants of metamorphic rocks within the granitic batholith. The pendants are remnants of Paleozoic and Mesozoic marine sedimentary deposits including limestone, shale, sandstone, limy mudstone, and interbedded volcanic rocks. These rocks were consolidated, folded, and dynamothermally metamorphosed prior to the invasion of the granite batholith in late Jurassic or early Cretaceous time. The roots of the pendants were largely digested by the granitic magma, and intense hydrothermal metamorphism recrystallized the remaining islands of metasedimentary rocks. In general, limestone was marbleized, shale was transformed into slate and hornfels, sandstone into quartzite, limy mudstone into calc-silicate hornfels, and interbedded volcanic rocks became amphibole schist and quartz-mica schist. Some impure calcareous rocks were silicated to form large masses of tactite. In some areas, the metamorphic rocks were completely digested and small xenoliths and irregular dark streaks through the granitic rocks are now the only evidence of their existence. These areas are referred to as migmatized zones.

The metamorphic pendants have been mapped in only three areas in Tulare County. Knopf and Thelan (1905) found Triassic fossils in some of the metamorphic rocks in the Mineral King pendant. Prout (1940) dated the pendants in the northern part of the Kernville quadrangle as Carboniferous. Cordell Durrell mapped the pendants around Three Rivers, but found no fossil evidence on which to date the rocks (Durrell 1940). One of the largest pendants in the southern Sierra Nevada has not been mapped. It underlies a large area at the headwaters of the Tule River. The lithology is very similar to that of the Paleozoic Calaveras formation which has been mapped as far south as Mariposa County. It is probable that most of the metamorphic pendants in Tulare County are made up of Paleozoic rocks.

Metamorphic rocks composed largely of serpentine and metavolcanic rocks are found in a belt along the foothills of the Sierra Nevada from Deer Creek northward. Limestone and quartz-biotite-chlorite schist are associated with these rocks. The rocks in this sequence have been folded, metamorphosed, and intruded by gabbro, norite, and granodiorite. This belt of metamorphic rocks has been mapped in the Yokohl Valley-Rocky Hill and Woodlake areas by Cordell Durrell, and divided into three rocks types and formations: metagabbro, serpentine, and Yokohl amphibolite (Durrell 1940). No fossil evidence was found on which to date the rocks, but they are lithologically similar to Jura-Triassic rocks farther north. Their relationship to the serpentine, their lithology, and their location along the foothills indicate that they are probably Jura-Triassic.

It is generally accepted that the granitic batholith was emplaced shortly after the invasion of the ultrabasic rocks from which the serpentine was formed. The most abundant rock type which composes the granitic batholith is biotite granodiorite; however, locally it grades into granite, quartz monzonite, quartz diorite, or gabbro-norite. Pegmatite dikes are widespread. The plutonic rocks are dated as late Jurassic or early Cretaceous.

The Sierra Nevada has been subjected to erosion since early Cretaceous time. Erosion which accompanied the uplift of the Sierra Nevada supplied a large quantity of detrital sediments to the Great Valley of California. Tertiary sedimentary rocks as old as Oligocene are known from oil-well test holes in the Terra Bella-Deer Creek area, and Miocene sandstone is exposed in a small outcrop at the extreme southern edge of Tulare County west of White River. With the exception of this outcrop, western Tulare County from the valley to the foothills is covered with unconsolidated Quaternary and Recent floodplain, terrace, and basin deposits. From the foothills eastward, Quaternary and Recent sediments are restricted to river gravels and terraces, and glacial debris filling lakes.

Some volcanic rocks of Tertiary-Quaternary age have been described by Prout (1940)and Webb (1950) in the northern part of the Kern quadrangle, along the Kern River, in Toowa Valley, and in the High Sierra west of Olancha. These rocks are predominantly rhyolitic and appear to have originated from local vents.

Summary of the Economic Geology. The metamorphic rock pendants are host for scattered contact and fissure vein deposits of tungsten,

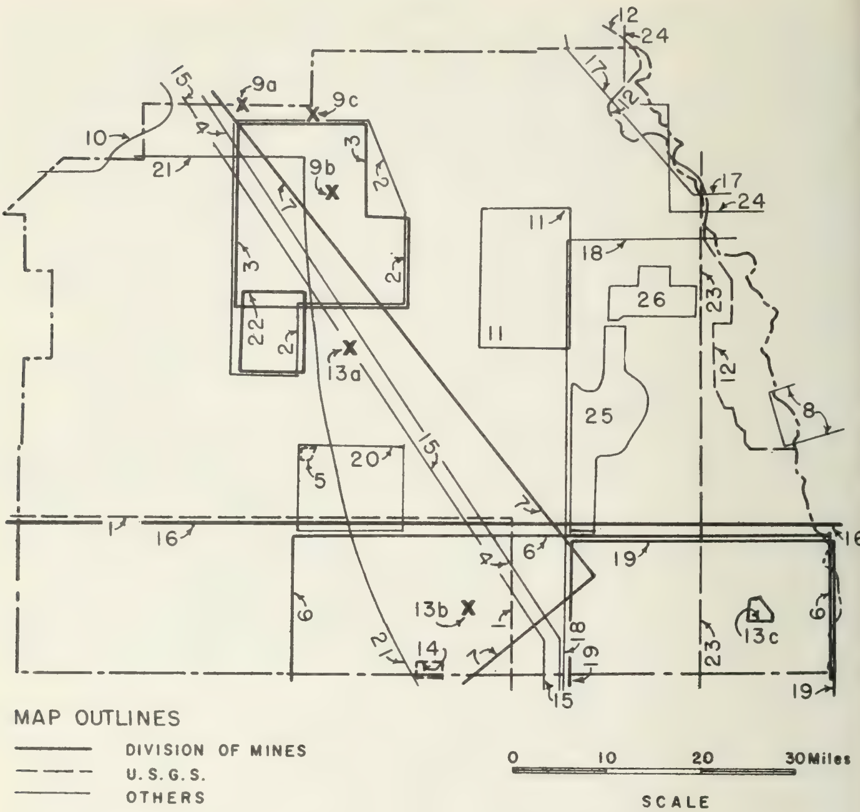

FIGURE 2. Index to geologic mapping, Tulare County.

lead, zinc, copper, molybdenum, and antimony. Of these metals, only tungsten has been of commercial importance to date. Scheelite is found in tactite (usually a garnet-epidote rock) along the margins and at the terminations of canoe-shaped pendants. They are referred to as contact deposits; however faulting and shearing are evident in all deposits examined, and where tactite is in normal contact with granitic rocks, little or no scheelite is found.

Large reserves of limestone exist within these pendants. To date there has been little development, mainly because of the inaccessibility. Some barite has been produced and large reserves of low-grade baritic limestone are known in the Nine-Mile Canyon area.

The serpentine bodies along the foothills in Tulare County have been a source of chromite, magnesite, chrysoprase, and some nephrite. Scattered occurrences of amphibole asbestos are reported. Garnierite (hydrous nickel, magnesium silicate) and nickeliferous magnesite in the lateritized serpentine and residual soils represent a source of nickel of unknown potential. Some copper has been found along shear zones within the foothill belt; however, development has been discouraging. Manganese is also present but of doubtful commercial value.

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Tulare County

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PHOTO 3. The southwest face of Moro Rock from Highway 198. The rounded granitic mass stands 6723 feet above sea level, affording a spectacular view of the Kaweah River gorges, the San Joaquin Valley, and the high peaks of the Sierra. Mount Whitney, whose western slope is in Tulare County, is among the snow-capped peaks visible from its crest. *Photo by Mary Hill.*

PHOTO 4. View of granitic mountains from Lodgepole, Sequoia National Park. The surrounding trees are lodgepole pines. *Photo by Mary Hill.*

Photo 5. Metamorphic rocks near Success. These rocks have not been mapped in detail and their age, though probably Jurassic or older, is not known. *Photo by Mary Hill.*

Photo 6. Detail of metamorphic rocks in photo 5. *Photo by Mary Hill.*

PHOTO 7. Serpentine exposed on Badger Hill. *Photo by Mary Hill.*

PHOTO 8. Contact of metamorphic rocks and the granitic batholith that has intruded them. Hillside to left, of more moderate and rounded relief, is underlain by metamorphic rocks that weather more uniformly and readily than the granitic mass of the hill to right. The actual contact of the two rock types is marked by a pronounced saddle. Southern slope of Rocky Hill east of Exeter. *Photo by Mary Hill.*

PHOTO 9. View across Happy Valley Ranch, Yokohl Valley. The fertile, alluvium-covered valley supports citrus groves and cattle. Wildflowers, which are abundant and colorful in the spring, are particularly prolific on slopes underlain by metamorphic rocks; in the background to the right, large light patches on the hillsides are wildflowers. The hill to the left is composed of granitic rock; a large sheeting surface is just above the ranch house. *Photo by Mary Hill.*

PHOTO 10. Landscape on granitic rock, Hungry Hollow road. *Photo by Mary Hill.*

PHOTO 11. Butte of "black granite" (gabbro) near Success. Field in foreground is abloom with mustard. *Photo by Mary Hill.*

PHOTO 12. Quartz vein cropping out east of Porterville on Tule Indian Reservation road. *Photo by Mary Hill.*

Commodities of commercial interest within the plutonic rocks are granite for building stone and rubble; disseminated bodies of molybdenite; scheelite in migmatized zones and in quartz veins within these zones; gold-bearing quartz veins in granite; and pegmatite dikes containing feldspar and uranium-thorium-bearing minerals.

The Cenozoic sedimentary rocks have been the source of the two most valuable groups of mineral commodities in the county—sand and gravel and oil and gas. Reserves of sand and gravel exist along the flood plains of the Kaweah and Tule Rivers. Known oil and gas reserves are not large, but natural gas from the Trico field has been the most valuable single commodity produced in Tulare County. Clay-bearing sediments containing material suitable for making common brick and tile are widely scattered throughout the unconsolidated valley sediments.

Distribution of Tertiary-Quaternary volcanic rocks is limited; they are of little commercial interest, mainly because of their inaccessibility. To date no mineral deposits of economic interest have been found in these rocks.

Table 1. Mineral production of Tulare County, 1880-1931.

Year	Gold, value	Silver, value	Brick		Gems, value	Granite		Magnesite		Miscellaneous stone[1], value	Miscellaneous and unapportioned		
			M	Value		Cubic feet	Value	Tons	Value		Amount	Value	Substance
1880	$1,125	$526											
1881	8,181	36											
1882	5,000	2,000											
1883	4,000	1,000											
1884	70,000												
1885	7,500												
1886	6,900	50											
1887	15,640	167											
1888	25,000												
1889	39,340	250											
1890	43,019												
1891	15,095												
1892	24,355	11											
1893	12,818												
1894						4,668	$10,000						
1895	16,320					3,000	2,500						
1896	20,092					2,800	4,700				80 tons	$960	Limestone.
1897	12,830	214				3,600	8,000				1,000 bbls.	1,500	Lime.
1898	12,400		300	$2,000		700	1,500						
1899	13,610		600	4,200		1,200	3,000						
1900	10,445	433	650	6,100		1,500	3,000	200	$1,500				[3]
1901	14,616	100	1,600	8,600		9,000	18,000	3,511	28,210				
1902	11,648		4,500	27,000	$500	1,790	4,000	2,450	19,250				
1903	9,215		1,500	9,500	500	3,000	2,260	1,300	19,600	$100			
1904	1,100		1,250	10,000		7,000	16,000	2,800	9,100			50,108	Unapportioned, 1900-1909.
1905	2,300	13	2,000	16,000	5,000	7,000	9,000						
1906	20		1,500	12,000	209,790	7,000	9,000						
1907			2,500	20,000	26,206			2,380	21,420				
1908			2,250	18,000	62,250			6,567	52,642				[3]
1909			6,620	42,400	58,000			6,468	47,200		2,803 lbs.	360	Copper.
												185	Natural gas.
1910			8,195	64,000	104,000	700	1,500	7,110	35,550		2,000 M cu. ft.	1,000	Natural gas.
1911			10,225	81,000	20,000			7,763	57,335				
1912			10,900	70,500	5,350			6,684	66,840		100 cu.ft.	200	Marble.
1913			6,000	45,000	1,500			7,858	62,864	4,350	80 tons	200	Quartz.
											392 cu. ft.	796	Marble.
											1,429 tons	5,050	Feldspar.
1914			6,838	47,507				9,650	96,500	1,750	1,250 tons	2,400	Quartz.
											2,830 tons	13,065	Feldspar.
											6 cu. ft.	30	Marble.
1915			5,520	33,364				11,574	104,166	36,851	1,349 tons	1,888	Limestone.
											1,800 tons	6,500	Feldspar.
												1,830	Chromite and silica.
1916			6,330	48,500		[2]	[2]	87,606	737,130	82,255	3,435 tons	42,555	Chromite.
											1,422 lbs.	350	Copper.
												36,410	Feldspar, granite, limestone, marble, silica.

1918	----------	----------	[2]	[2]	[2]	[2]	[2]	28,826	269,748	125,407	600 tons	24,000	Chromite.
											444 tons	2,928	Feldspar.
											8,400 tons	32,400	Limestone.
											204 tons	1,143	Silica.
											----------	71,782	Brick, gems, granite, soapstone, talc, tile.
1919	----------	----------	and tile	34,978	----------	[2]	[2]	18,765	186,601	10,811	10,347 tons	46,388	Limestone.
											700 M cu. ft.	295	Natural gas.
											----------	51,928	Chromite, feldspar, granite.
1920	----------	----------	[2]	[2]	----------	----------	----------	35,305	394,169	8,465	400 M cu. ft.	195	Natural gas.
											----------	190,467	Brick, feldspar, granite, limestone.
1921	----------	----------	----------	----------	----------	[2]	[2]	11,454	125,594	284,122	10,030 tons	40,090	Limestone.
											380 M cu. ft.	190	Natural gas.
											----------	102,238	Brick and granite.
1922	----------	----------	[2]	[2]	----------	[2]	[2]	17,223	181,842	151,000	380 M	190	Natural gas.
											----------	189,662	Brick, tile, granite, limestone.
1923	----------	----------	[2]	[2]	----------	[2]	[2]	24,058	298,272	1,990	380 M	190	Natural gas.
											15,500 tons	57,500	Limestone.
											----------	108,607	Brick, granite.
1924	----------	----------	[2]	[2]	----------	[2]	[2]	21,203	271,830	80,411	1,080 M	540	Natural gas.
											----------	145,893	Brick, hollow tile, granite, limestone.
1925	----------	----------	[2]	[2]	----------	----------	62,260	18,150	245,557	47,176	280 M	175	Natural gas.
											13,300 tons	43,900	Limestone.
											----------	27,911	Brick, lime.
1926	----------	----------	[2]	[2]	----------	[2]	[3]	13,378	138,347	73,881	593 tons	7,709	Lime.
											18,000 tons	70,000	Limestone.
											----------	107,983	Brick, hollow tile, granite, natural gas.
1927	----------	----------	[2]	[2]	----------	[2]	[2]	[2]	[2]	15,082	----------	459,091	Brick, hollow tile, granite, lime, limestone, magnesite.
1928	----------	----------	[2]	[2]	[2]	[2]	[2]	[2]	[2]	108,419	----------	336,947	Brick, gems, granite, lime, limestone, magnesite.
1929	----------	----------	[2]	[2]	----------	[2]	[2]	[2]	[2]	24,932	----------	262,949	Brick, granite, limestone, magnesite.
1930	$36	$311	----------	----------	[2]	[2]	[2]	[2]	[2]	74,500	----------	178,297	Gems, granite, limestone, magnesite, petroleum.
1931	244	2	[2]	[2]	[2]	[2]	[2]	[2]	[2]	75,778	----------	121,092	Barite, brick and building tile, gems, granite, magnesite, limestone, petroleum.
Totals	$402,849	$5,113	[2]86,049	[2]$713,587 (includes Tile)	[2]$493,096	[2]52,958 (includes some linear feet of curbing)	[2]$154,720	[2]488,845	$4,710,120	$1,282,874	----------	$2,920,652	

[1] Includes crushed rock, rubble, sand, gravel.
[2] See under 'Unapportioned.'
[3] Gypsum previously reported for years 1900 and 1907 was from Kern County.

Table 1. Mineral production of Tulare County, 1932-55 (cont.).

Year	Natural gas		Petroleum		Sand and gravel (includes crushed rock)		Tungsten		Miscellaneous[4]	
	Million cubic feet	Value (dollars)	Barrels	Value (dollars)	Tons	Value (dollars)	Units WO_3	Value (dollars)	Material	Value (dollars)
1932			410	226	67,773	72,541	1,600	9,300	Gold and silver	142
									Barite, clay, copper, gems, granite, and lime	33,865
1933			2,390	1,525	130,517	136,859	1,841	12,404	Gold and silver	2,166
									Clay and granite	24,659
1934			1,815	1,034	164,839	139,875	1,326	22,200	Gold and silver	5,208
									Barite, clay, and gems	16,025
									Copper and lead	132
1935	4,731	372	2,708	1,579	55,763	27,067			Gold and silver	961
									Barite, clay, and granite	23,452
1936	6,773	474	2,972	1,505	242,551	174,273			Gold and silver	886
									Clay, granite, lead, copper, and zinc	32,830
1937	3,189	225	1,588	1,112	178,453	136,539	7,632	152,640	Gold and silver	1,059
									Clay, chromium, and gems	23,377
1938	13,457	1,345	1,320	924	219,710	151,788	7,140	105,000	Clay, gold and silver	14,142
1939	1,612,221	117,870	1,000	650	121,440	46,983	15,480	263,160	Clay, gold and silver	23,884
1940	767,466	45,497			21,218	14,164	11,341	222,094	Clay, gold and silver	20,700
1941	1,111,645	70,492	200	133	213,381	101,470	2,870	64,461	Gold and silver	2,665
									Barite and clay	33,440
1942	1,112,185	75,315	600	438	38,298	30,298	2,067	54,162	Gold and silver	4,731
									Clay and manganese	30,965
1943	1,687,572	94,818	150	132	91,866	81,188	15,470	417,487	Silver	346
									Clay and manganese	16,616
1944	3,468,232	195,022			253,897	170,681	13,501	332,008	Clay and gems	43,212
1945	1,334,345	95,453			200,703	159,400	2,395	55,085		
1946	2,988,790	344,241			238,926	207,396	5,035	117,696		
1947	2,070,007	398,556			312,195	368,099	7,438	170,893		
1948	10,672,000	1,465,000			302,589	388,970	8,290	197,025	Clay, gold and silver	6,750
1949	5,325,000	726,000			888,165	924,732	3,606	85,141	Clay, gold and silver	3,014
1950	3,427,000	453,000	564	930	442,942	515,492	4,923	138,887	Clay, gold and silver	8,106
1951	4,876,910	872,000	842	1,376	485,467	526,201	2,664	150,002	Clay, copper, and silver	6,566
1952	5,482,881	1,159,919	425	740	497,744	555,797	3,944	242,556	Clay, copper, and silver	3,064
1953	4,871,897	1,065,502	782	1,564	416,650	510,533	4,002	250,325	Clay, lead, zinc, and silver	6,123
1954	5,654,560	1,165,000	43,098	85,774	283,591	385,226	6,639	416,133	Clay and barite	77,454
1955	6,394,750	1,318,000	63,848	129,611	436,611	575,130	7,708	474,813	Clay and barite	47,570
Totals	62,885,611	[1]9,664,101	[1]124,712	229,253	[2]6,305,289	6,401,242	[3]136,912	3,953,472		514,080

GRAND TOTAL 1880-1955—$31,445,159.

[1] For minor oil and gas production prior to 1932 see production statistics 1890-1931 under miscellaneous and unapportioned.
[2] Sand, gravel and crushed rock figures include noncommercial production of federal, state, and county agencies; tabulated as miscellaneous stone prior to 1932.
[3] Tungsten production figures have been revised and therefore may not agree with previously published figures.
[4] Unapportioned values under miscellaneous are combined to conceal production of single producers. Clay values prior to 1950 refer to clay products and do not therefore represent true value of raw clay.

MINES AND MINERAL RESOURCES

The total value of the mineral production of Tulare County between 1880 and 1955 was $31,445,159. The greater part of this value was from the production of natural gas and nonmetallic minerals. Though several nonmetallic mineral industries have become important to the economy of Tulare County in the past, none has survived long, with the exception of the sand and gravel industry. Changing economic conditions and changing demands of the industrial minerals industry have forced the decline or cessation of these industries.

The magnesite industry, begun about 1900, reached its peak during World War I and ended in 1931. During this period 538,296 tons of crude magnesite, having a value of $5,170,301, was produced. Much of the magnesite was calcined within the county. Processing approximately doubled the value of the commodity.

Other nonmetallic mineral industries of relatively short duration were the granite industry, 1900-37, with a total valuation of $769,216; and the gem stone (chrysoprase) industry, 1895-1913, during which time $493,096 worth of gem-quality chrysoprase was marketed.

The most consistent contributors to the county's mineral production, in addition to the natural gas industry, have been the producers of clay, sand, gravel, and crushed rock. As elsewhere, the production of these materials closely parallels the increase in population.

In recent years the production of tungsten concentrates has materially supplemented the county's mineral production and has done much to revive interest in the mining industry. The total production of tungsten from 1932-55 was 136,912 units of WO_3 valued at $3,953,472.

Other minerals and mineral products which have been produced sporadically and in relatively small quantities include: among the metals, chromite (mainly during World War I), copper, gold, lead, manganese, silver, and zinc; among the nonmetals, barite, feldspar, limestone, and silica. Some petroleum also has been produced in recent years from the Deer Creek-Terra Bella area, and Deer Creek has recently acquired the status of a field.

Mineral materials known to exist in Tulare County, but which have not been found in commercial quantities, include antimony, asbestos, graphite, iron, molybdenum, nickel, radioactive minerals, phosphate rock, and sulfur (in the form of pyrrhotite).

The total mineral production of Tulare County is no true measure of the county's mineral potential, as the entire eastern half of the county is virtually undeveloped; the petroleum resources of the valley are only partially developed, and the development of the structural-material resources are stunted by geographic location.

Metals

Antimony

The chief ore mineral of antimony is stibnite (antimony sulfide, Sb_2S_3), which is found both in fissure veins and in replacement pods in metasedimentary rocks. The commonly associated gangue minerals are quartz and pyrite. Stibnite in quartz veins in slate has been found at two localities in the Mineral King district. No production is recorded.

Chromite

Chromite, the only ore mineral of chromium, has been found as small masses in serpentine along the low rolling foothills from Porterville north to Rocky Hill. The total recorded production is 4,485 long tons of lump ore valued at $77,555, all of which was mined prior to 1919.

Commercially valuable deposits of chromite are found only in peridotite and in serpentine derived from peridotite. These deposits may consist of relatively pure masses of chromite, or the ore may be disseminated as grains, nodules, or stringers in the host rock. Massive ore may be sold without concentration if it meets commerical-grade specifications, but disseminated ore must be milled and concentrated to yield a marketable product.

Chromite ore produced from Tulare County has been entirely of the massive type; no deposits of disseminated ore have been reported. Known reserves are negligible. The lack of production since 1919, during periods when chromite commanded high prices, indicates that the odds are not good that important deposits will be found in the future. However, further exploration in the vicinity of previously mined ore bodies may lead to the discovery of some additional ore.

Gill Ranch Chromite Deposits. Location: SE$\frac{1}{4}$ NW$\frac{1}{4}$ section 16, T. 19 S,. R. 27 E., M.D., at the south end of Yokohl Valley in the Rocky Hill quadrangle. Ownership: Gill Brothers Cattle Company.

Chromite was found in a series of lenses in altered serpentine along a northwest-trending zone. The serpentine is banded by seams of talc, magnesite, and chlorite. A total of 400 long tons of ore containing 40 percent Cr_2O_3 was mined by open cuts and shallow tunnels 35 to 90 feet long. The largest body of ore was 2 feet by 12 feet by 30 feet. The dip of the ore pods ranged from 50° SW to vertical. Other development work included a 35-foot shaft. The property has been inactive since World War I.

Holston (Vaughn, Vaughn Ranch) Chromite Deposit. Location: S$\frac{1}{2}$ section 9, T. 22 S., R. 28 E., M.D., elevation 650 to 880 feet on the south slope of the ridge north of Dry Creek, 4 miles southeast of Porterville in the Kaweah quadrangle. Ownership: Mrs. Charles Holston.

Between 1915 and 1918 about 3300 long tons of chrome ore containing 45 to 50 percent Cr_2O_3 was mined from three separate groups of ore lenses. The lenses were in sheared serpentine adjacent to a gabbro stock and paralleling the schistosity of the serpentine. The strike of the ore lenses was N. 20°-30° W. and the dip 70° SW. The two largest open cuts were 100 by 10 by 5 feet and 60 by 30 by 15 feet. The third ore body was developed and stoped from a 75-foot adit and raise; the glory hole is 45 feet by 10 feet, and is 20 feet deep. This property was first operated about 1895. Inactive since World War I.

Lewis Hill Chromite Prospect. Location: SW$\frac{1}{4}$-NW$\frac{1}{4}$ section 13, T. 21 S., R. 27 E., M.D., on the south spur of Lewis Hill at an elevation of 750 to 800 feet, about 2 miles north of Porterville in the Porterville quadrangle. Ownership: undetermined.

A small pod of massive chromite with included fragments of sheared serpentine has been mined from a large body of sheared serpentine on the south side of Lewis Hill. The prospect pit is 30 feet long, 10 feet wide, and about 20 feet deep. An adit has also been driven 108 feet from a point about 150 feet from the pit and at an elevation about 60 feet lower. This adit was driven from a 30-foot open cut from which some ore may have been removed. The adit has a heading of N. 32° W. and is in sheared serpentine all the way. It does not appear to have cut any ore and was not driven toward any visible structure or mineralized area. The only chromite observed in place was in narrow bands remaining in the vertical walls of the upper pit. This work was probably done during World War I.

Copper

Twenty-eight copper prospects have been reported from Tulare County. These are grouped in three districts; most lie in the Camp Wishon and Mineral King districts, but a few are found in the foothills between Fountain Springs and Rocky Hill. Two distinct types of deposits are known. The largest contain chalcopyrite associated with sphalerite, pyrite, and other sulfides in contact and replacement bodies within and along the contacts of pendants of metasedimentary rocks within the Sierran granitic batholith in the Camp Wishon (North Fork of Middle Fork Tule River) and Mineral King districts. The second type of deposit consists of fissure veins in a complex series of basic and ultrabasic rocks interfolded with metavolcanic rocks, schist, and slate, all of which are intruded by granitic igneous rocks. These deposits, found mostly along the foothills from the vicinity of Fountain Springs northwest to Rocky Hill, may represent a feeble southward continuation of the Sierra Nevada foothill copper belt.

None of the 28 known occurrences has been developed beyond the prospect stage, and the total copper production to date has been only 9,129 pounds recovered from trial lots of ore shipped to smelters. The known potential is not great, and the inaccessibility of the Camp Wishon and Mineral King deposits has hindered development.

Hamilton Copper. Location: NE¼ SW¼ section 33, T. 18 S., R. 27 E., M.D., about 1 mile east of the Hamilton Ranch House, Yokohl Valley, in the Rocky Hill quadrangle; elevation 700 feet. Ownership: Hamilton Ranch, Yokohl.

The Hamilton Ranch copper prospect is similar to, if not typical of many of the Sierran foothill copper belt occurrences. Chalcopyrite intimately associated with pyrrhotite is found in a shear zone in metavolcanic rocks near the contact with a dike of sheared granite gneiss. The dike is about 50 feet wide in the vicinity of the prospect. Shearing and copper mineralization occur on either edge of the dike. The main shear zone on which most of the prospect development has been done strikes N. 80° W. and dips from 75° N to vertical. Development consists of a 110-foot shaft with a 20-foot crosscut in the footwall, a 6-foot pit, and several shallow cuts. Along the shear zone, talc and sericite have developed. The zone is heavily stained by azurite, malachite, limonite, and hematite. Some sulfides were found below 60 feet. The crosscut into the footwall is in unaltered meta-andesite which contains

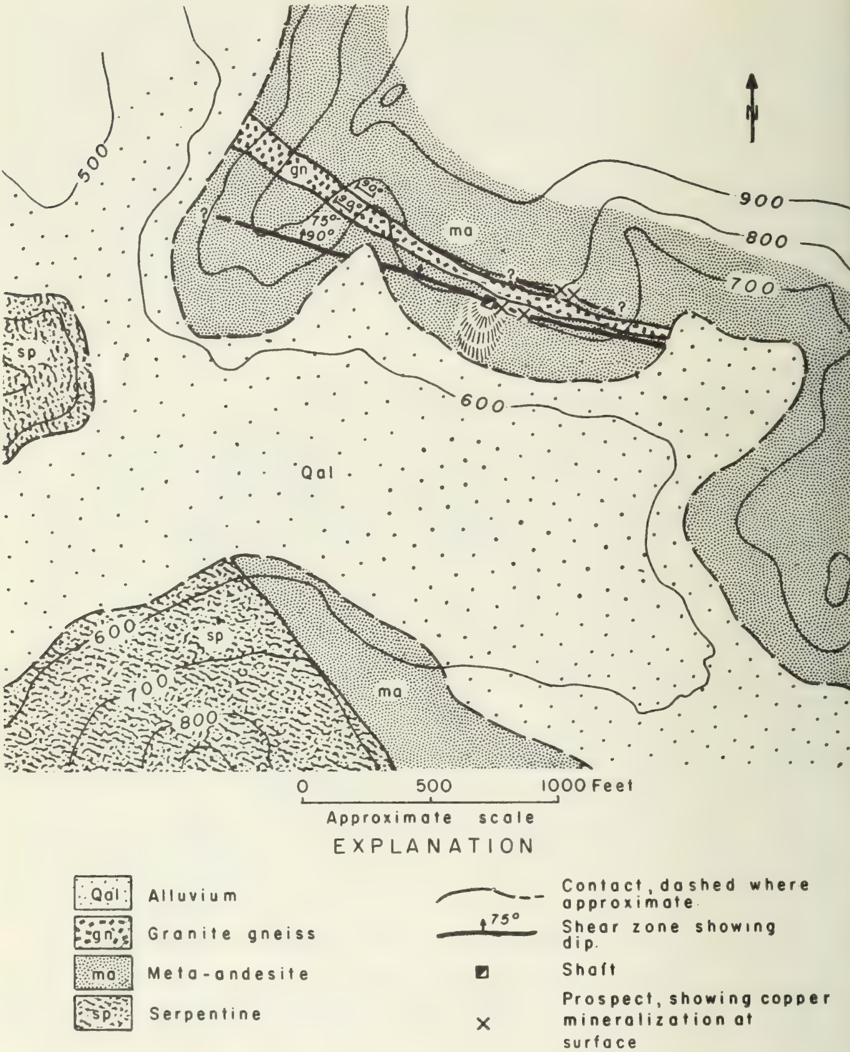

FIGURE 3. Geologic map of Hamilton copper prospect.

disseminated pyrrhotite and chalcopyrite. The shear zone can be traced at least 1,000 feet to the west of the shaft and at least 500 feet to the east. The parallel shear zone on the north side of the dike does not appear to be as strong as the main shear zone. Ore from the sulfide zone was said to contain 6 percent copper, and some gold and silver. The property has been inactive since World War I.

Round Valley Copper. Location: SE¼ section 3, T. 20 S., R. 27 E., M.D., in Round Valley 3 miles east of Lindsay in the Lindsay quadrangle. Ownership: C. H. Cannon, Lindsay.

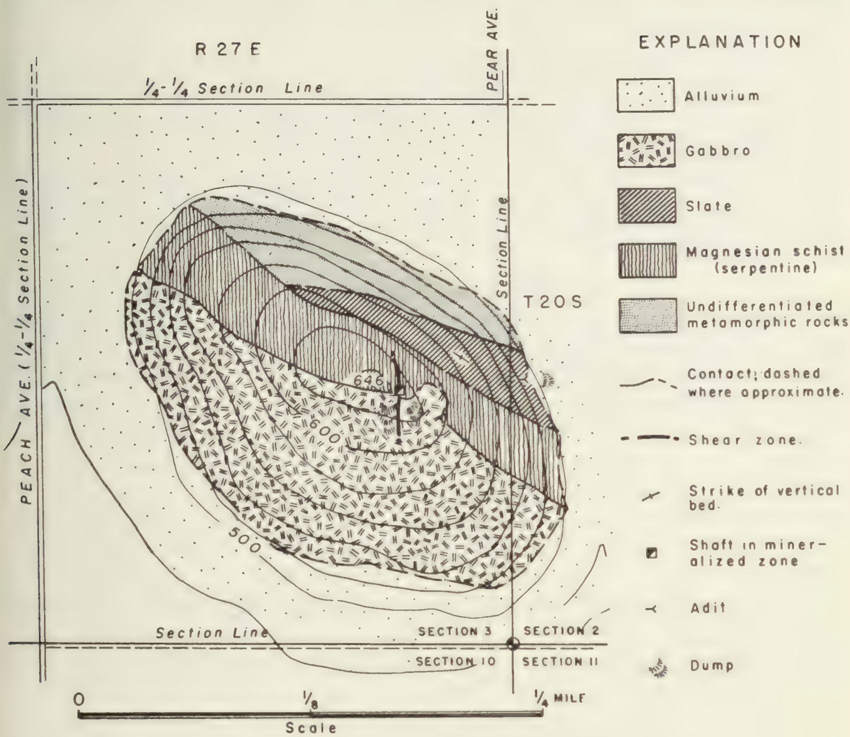

FIGURE 4. Geologic map of Round Valley copper prospect.

The Round Valley copper prospect is located on top of a small hill in alluvium-filled Round Valley. It was last reported active in 1916 (Tucker, 1919, p. 910). Azurite and malachite occur along a north trending shear zone for a maximum observed distance of 20 feet. The maximum width of the zone, as exposed in a 30-foot shaft, is about 3 feet. The fault gouge is mineralized and is composed largely of jarosite and clay with azurite and malachite. The mineralized zone is at the point where the shear zone crosses the contact between a magnesian schist (altered serpentine) and intrusive gabbro. Neither the mineralization nor the shear zone could be traced beyond the immediate vicinity of the prospect shaft. A now inaccessible adit was driven toward the mineralized zone from a point about 100 feet lower in elevation and about 300 feet to the northeast. The material in the dump indicates that the mineralized zone was not reached.

Gold

Gold was first discovered in Tulare County in the White River district in 1853 by D. W. C. Biggs and A. J. Maltley (Tucker 1919, p. 912). The gold is in quartz veins in granite and metasedimentary rocks

in the western part of the district. The quartz veins and the enclosing metasedimentary rocks strike northeast; the predominant dip of the veins is northwest.

There is no record of the production of gold prior to 1880, but since that time the total value of the gold produced is about $430,000. The peak year of production was 1884, when $70,000 worth of gold was recovered, and the period of activity lasted until 1906. There was a slight revival in the 1930's, but since that time the district has been dormant. The ore was, for the most part, free milling; however, auriferous sulfides were reported. A small portion of the gold came from placer operations.

A total of about 50 gold mines and prospects has been reported in the county; however, only those mines in the White River district have had any significant production. Most of the land in the White River district is used for agricultural purposes, and large parcels are under single ownership. Many of the gold mines described in previous reports on Tulare County actually are in Kern County.

Lead

See under *Zinc*.

Manganese

Manganese is found (mainly as the oxides pyrolusite and psilomelane) at widely scattered localities throughout Tulare County. Manganese oxides are common in zones of hydrothermal alteration in all rock types and are especially prominent along fault zones in the foothills where ultrabasic, metavolcanic, and metasedimentary rocks have been invaded by granitic igneous rocks. Five deposits of possible commercial interest have been reported along the foothills. During 1942 and 1943 some manganese ore was produced.

Molybdenum

The only important ore mineral of molybdenum is its sulfide molybdenite (MoS_2). Molybdenite is a fairly common accessory mineral in acid igneous rocks, particularly in granitic and pegmatitic bodies. It may be in veins, stockworks, or disseminations. The most common occurrence in Tulare County is disseminated molybdenite in granite. Molybdenite also is commonly associated with other sulfides in contact metamorphic deposits. It is present in some of the tungsten mines in Tulare County, and is recovered at the Pine Creek mine in Inyo County, near the Tulare County line. There is no recorded production from Tulare County.

Nickel

Nickel-bearing deposits have not been reported previously from Tulare County. During examination of chrysoprase localities in bodies of lateritized serpentine along the foothills of the county, numerous veinlets of garnierite (hydrous nickel, magnesium silicate) were discovered in association with the chrysoprase. The localities examined include Venice Hills east of Ivanhoe, Todd and Chrysoprase Hills east of Lindsay, and Tennessee Ridge (Deer Creek chrysoprase) southeast

of Porterville. Garnierite appears to be much more abundant than chrysoprase in these areas, though usually it is more difficult to recognize because of the masking effect of limonite in weathered zones. Garnierite was found at all of the gem localities, where it had been rejected along with waste rock because of its inferior hardness. Iron-rich soil overlying these deposits was also found to contain nickel. In addition, nickel-bearing magnesite veins were found near Deer Creek. These veins have a pale yellow-green color in contrast to the white veins of normal magnesite.

The origin of these deposits is believed to be closely related to that of the magnesite deposits, and similar to the Nickel Mountain deposit at Riddle, Oregon (Pecora and Hobbs, 1942).

Serpentine, a hydrous silicate of magnesium containing variable amounts of iron, chromium, and nickel, is slowly decomposed by the action of ground water to form soluble magnesium compounds which migrate downward. Much of the magnesium is dissipated; however some is precipitated as white magnesite (magnesium carbonate) or as nickeliferous magnesite in broken serpentine below the weathering zone. Silica and iron remain in the weathered outcrop to form a brown, iron-stained silica boxwork and jasperoid, the latter being silicified serpentine. Some of the nickel is deposited in veins as a hydrous nickel-magnesium silicate of the garnierite type, and remains behind in the silica boxwork or silicified serpentine underlying it. In this way a rock originally containing a fraction of one percent nickel may be enriched to several percent nickel by removal of the diluting elements. Garnierite is a soft friable mineral and usually does not persist in the outcrop. In the localities mentioned it was found only in recent excavations.

Deer Creek Nickeliferous Magnesite. Location: SE ¼ SE ¼ section 21, and NE ¼ NE ¼ section 28, T. 22 S., R. 28 E., M.D., in the White River quadrangle at the north end of Tennessee Ridge. Ownership: Mr. Claude Slaughter, Success, California.

Nickel-bearing magnesite occurs in association with normal magnesite in a group of prospects in magnesium-rich metamorphic rocks (presumably altered serpentine) near Deer Creek. These rocks are composed of a slightly schistose aggregates of limonite-stained talc and magnesite with minor chalcedony, cordierite, andalusite, and disseminated magnetite. The crest of the hill in which the prospects are located is void of soil and vegetation and is erosion-resistant because of the presence of closely spaced magnesite veinlets about 1 inch wide. Several small bodies of amphibolite, composed almost entirely of hornblende, are within the magnesian rocks. The large hill to the southwest is underlain by amphibolite, with the exception of two small lenses of magnesite-veined magnesian rocks. The intervening saddle is underlain by metamorphic rocks including chlorite schist and andalusite-cordierite schist. Metamorphic rocks also are in contact with magnesian rocks on the east side.

Pale yellow-green nickeliferous magnesite associated with normal white magnesite was observed in several of the prospects. The principal occurrence is in an open cut about 6 feet wide, 12 feet deep, and 50 feet long. The maximum width of the nickel-bearing veins is 2 inches. Most of the veins are nearly horizontal, and all are in the lower half of the 12-foot face exposed beneath a flat-lying 6-inch vein

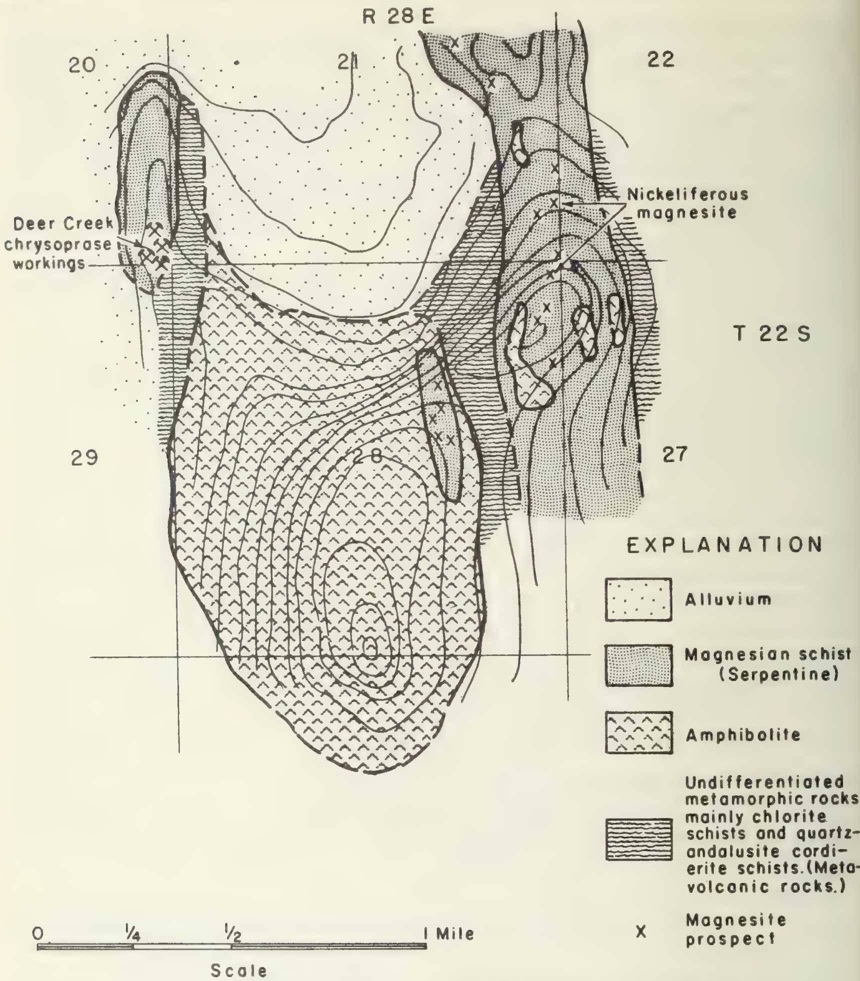

Figure 5. Geologic map of Deer Creek nickeliferous magnesite deposit.

of normal white magnesite. Samples of the nickeliferous vein material, of the wall rock between veins in the lower half of the cut, and of the wall rock capping above the 6-inch vein of normal magnesite were found to contain 1.08, 0.58, and 0.15 percent nickel respectively. Nickeliferous magnesite does not appear in the wall rock capping above the 6-inch magnesite vein. It appears that leaching of the nickel has occured above this impervious horizon. The depth to which the nickeliferous veins extend is not known. Considering the number of magnesite prospects in the immediate vicinity which do not show any nickel-bearing magnesite, it appears likely that no great amount of nickeliferous magnesite is present.

The nickeliferous magnesite was examined by Dr. Adolph Pabst at the University of California, who found that it showed an X-ray

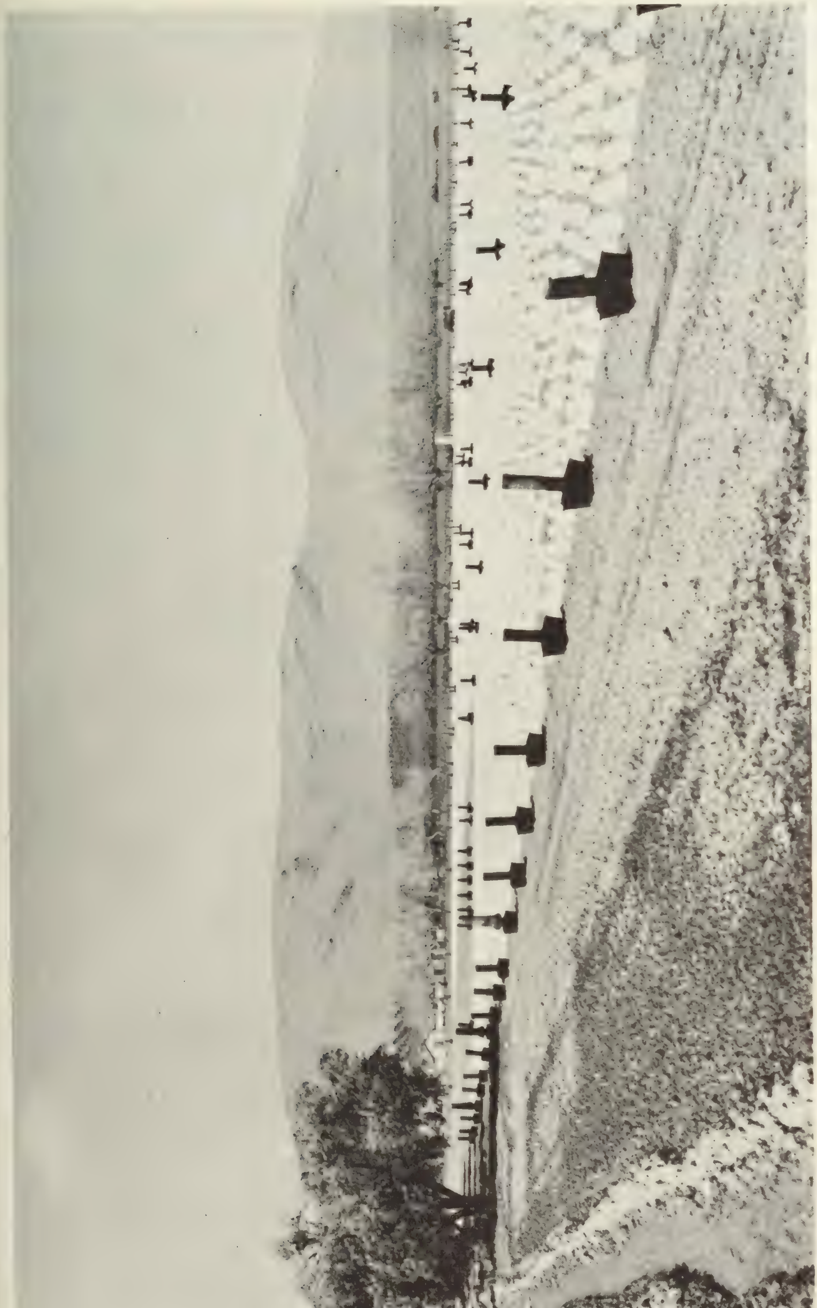

PHOTO 13. View of Venice Hills from southeast. Nickel prospects and chrysoprase-bearing outcrop are near crest of hill. *Photo by Mary Hill.*

pattern nearly identical to pure magnesite from Austria. Therefore it appears likely that nickel is substituting for magnesium in the magnesite structure.

Venice Hills Nickel. Location: SW¼SW¼ section 4, SE¼SE¼ section 5, NE¼NE¼ section 8, and the NW¼NW¼ section 9, all in T. 18 S., R. 26 E, M.D., 2½ miles due east of Ivanhoe in the Ivanhoe quadrangle. Ownership: Uota Brothers Ranch, Box 247, Ivanhoe; Wilmot Baumann, Woodlake; Sam Newman, Visalia; and Harry Fisher, Visalia. The property, with the exception of Uota Brothers Ranch, is under lease by Diversified Exploration Company, Mr. M. T. Williams, Lemon Cove.

The north end of Venice Hills is underlain by lateritized ultrabasic rock capped by residual jasperoid and silica boxwork. Meta-volcanic rocks with some lateritized ultrabasic rocks are exposed over most of the south end of these hills. The hills rise about 450 feet above the large alluvium-filled valley at the mouth of the Kaweah River. The highest peak is 865 feet above sea level.

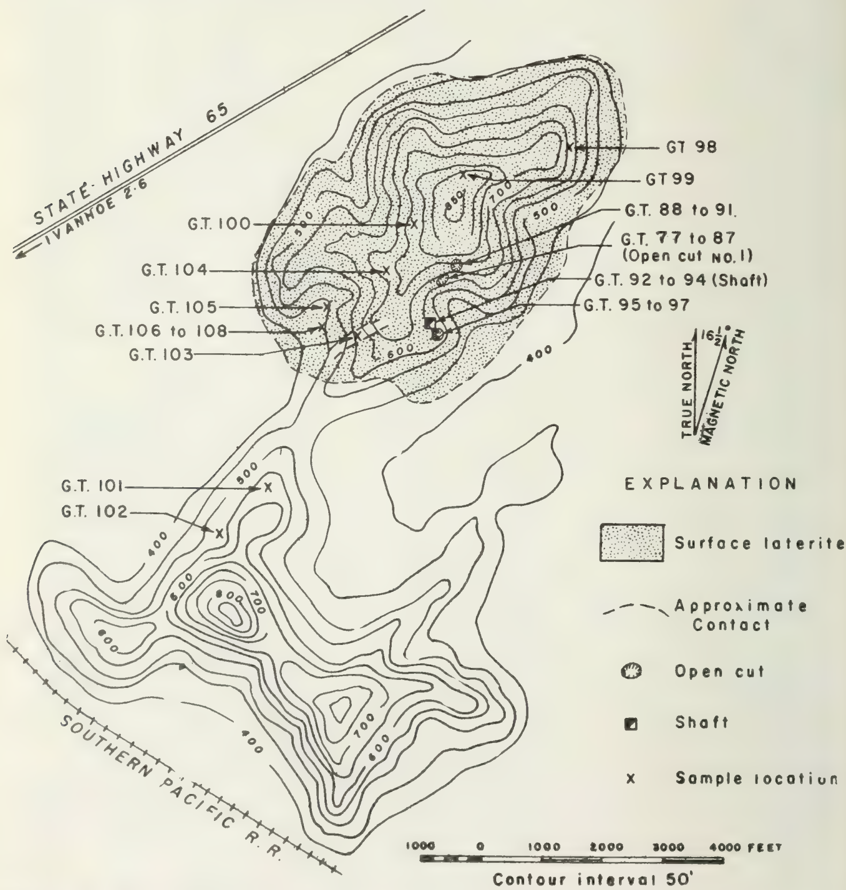

FIGURE 6. Map of Venice Hills nickel area showing locations at which samples were taken.

Veins of chrysoprase in the siliceous capping led to the discovery of adjacent veinlets of garnierite (hydrous silicate of nickel and magnesium). They occur mainly along flat-dipping fractures in a sandy matrix of silica, talc, and oxides of iron. Some veinlets also occur in the jasperoid which caps the hill. Exposed veins were found only in recent excavations in sheltered areas beneath overhanging ledges of siliceous cap rock.

Garnierite was found to be widely distributed throughout the decomposed rock underlying the jasperoidal material. Garnierite seams in old excavations show delicate banding from white to blue-green. The material is brittle, has a dull earthy lustre, and a hardness of about 2½ to 3. Samples of this material were found to contain 20.19 percent nickel. Some veinlets are separated from the walls of the fracture by a thin shell of yellow-green nontronite. The maximum observed width of veins is about 2 inches. Near the surface these veins pass, both laterally and vertically, through a siliceous phase into material described as chrysoprase.

Fresh veinlets of garnierite exposed in a test pit have an entirely different appearance from the partially dehydrated and bleached surface exposures. The mineral is apple green in color, has a hardness of 1, and a waxy lustre. The fresh mineral much resembles green montmorillonite.

Grades of Field Samples—Venice Hills, Calif.

		Ni + Co
	Open cut #1—north wall	
G.T. 77	Vertical channel 0.0′ to 1.0′	0.184
G.T. 78	" " 1.0′ to 3.0′	0.149
G.T. 79	" " 3.0′ to 6.0′	0.520
G.T. 80	" " 6.0′ to 9.0′	0.525
G.T. 81	" " 9.0′ to 12.0′	0.434
G.T. 82	" " 12.0′ to 15.0′	0.322
G.T. 83	" " 15.0′ to 18.0′ (floor of cut)	0.447
G.T. 84	" " 0.0′ to 5.0′ (pit in floor, N. side)	0.705
G.T. 85	" " 0.0′ to 5.0′ (pit in floor, S. side)	1.078
G.T. 86	" " 0.0′ to 3.5′ (auger hole in pit)	0.370
G.T. 87	Selected garnierite specimens	
	Open cut #2 (200′ north of open cut #1)	
G.T. 88	Vertical channel 3.0′ to 6.0′	0.444
G.T. 89	" " 6.0′ to 9.0′	0.619
G.T. 90	" " 9.0′ to 10.0′	0.198
G.T. 91	" " 10.0′ to 12.0′ (bottom)	0.296
	Shaft location	
G.T. 92	Channel 2.0′ to 6.0′	0.888
G.T. 93	" 6.0′ to 10.0′	0.465
G.T. 94	" 10.0′ to 13.0′	0.837
	Open cut #3 (20′ east of shaft)	
G.T. 95	Channel 1.0′ to 7.0′ (bottom)	1.143
G.T. 96	Grab sample	0.330
	Surface chip samples	
G.T. 97	Indurated laterite with garnierite seam	0.689
G.T. 98	Silicified material	0.161
G.T. 99	Jasperoidal material	0.151
G.T. 100	Quartz boxwork	0.248
G.T. 101	Serpentinized peridotite	0.214
G.T. 102	Rock sample from south hill	Not assayed
G.T. 103	Rock sample from dike	" "
G.T. 104	Jasperoid rock specimen	" "
	Drill hole #1	
G.T. 105	2.0′ to 5.0′ (bottom)	0.153
	Drill hole #2	
G.T. 106	2.0′ to 10.0′	0.427
G.T. 107	10.0′ to 14.0′	0.374
G.T. 108	14.0′ to 17.0′ (bottom)	0.514

PHOTO 14. Magnesite veins in pit, north end of Venice Hills. Chrysoprase, discovered in 1878, was mined from the hills for several years. Re-examination of the chrysoprase in recent years led to the discovery of associated garnierite. *Photo by Mary Hill.*

Venice Hill was examined and sampled by a mining company in January 1956, but they did not find the deposit of economic interest at present. Samples were taken from near the surface at several points on the northern part of Venice Hill. Assays of these showed the content of nickel plus cobalt ranged from 0.149 percent to 1.143 percent. The cobalt content is insignificant. The deepest sample was from a depth of about 17 feet. Assays in general, show an increase in nickel content with depth. Near-surface leaching appears to have removed much of the nickel from the outcrops.

Tungsten

The principal ore minerals of tungsten are scheelite (calcium tungstate, $CaWO_4$), wolframite ($(Fe, Mn) WO_4$), and ferberite ($FeWO_4$). Of these only scheelite has been commercially important in Tulare County. Scheelite was reported in Tulare County as early as 1914 (Eakle, 1914) from a locality east of Visalia. Tungsten was first produced from the Kennedy tungsten mine (later known as the Tungstore mine) near Posey, in 1932. This property was prospected and partially developed as early as 1929 (Franke, 1930, p. 464).

Since World War II, when the development of domestic sources was encouraged by higher prices, about 56 mines and prospects have been reported in Tulare County. Of these, 30 are known to have produced. The total production of the county through 1955 was 136,912 units,

the bulk of which was produced by Consolidated Tungsten, Tulare County Tungsten, and the Tungstore mines. Immediately following World War II a price drop closed most mines. The second period of activity began with the Korean conflict when the government subsidized the price at almost triple the world market value. Tungsten mining activity declined during the spring of 1956 because the government stockpile was near completion. A new government purchase program enacted in 1956 set the price at $55.00 per short ton unit of contained WO_3. Appropriations were insufficient to complete the program, and most mines and mills were idle in 1957.

During 1954 there were 16 mines and 7 mills active within the county. Five of the mills were doing some custom work. Some ore was trucked out of the county to be milled in Fresno County or Kern County, and some Fresno County ores were trucked to custom mills in Tulare County. Scheelite concentrates and small lots of high-grade ore were further procesesd at Fresno or Bishop.

During World War II, Twining Laboratory in Fresno established a complete line of service to small tungsten producers. These services included assaying, milling and concentrating (small high-grade lots), roasting, magnetic separation, sampling, bagging, and storage. The two largest mills (Consolidated and Tulare County) have since installed their own roasting and magnetic-separation equipment and were doing some custom work in 1956.

During 1956, most of the tungsten mining, hauling, and milling was done on a contract basis in the county. The average contract cost for driving development headings and for stoping in hard rock was about $5.00 per ton. Hauling was contracted at about 33 cents per ton mile. Custom-milling charges ranged from about $8.00 to $12.00 per ton. The average charge for magnetic separation was approximately $5.00 to $6.50 per operating hour of the magnetic separator. Most tungsten ores from Tulare County mines do not require roasting, as the chief gangue minerals are garnet and epidote.

Tungsten ores in Tulare County are of three general mineralogical types occurring in two principal structural environments. The most important by far is scheelite without appreciable sulfides in the silicated margins of calcareous roof pendants. In most cases shearing and faulting along the margins of metasedimentary pendants are conspicuous and appear to be necessary prerequisites in these deposits. The richest ore often is associated with zones of intense silicification. The most common gangue minerals are quartz, garnet, epidote, and pyroxene; however, diopside and wollastonite also appear. The second most important type of occurrence is scheelite in a quartz gangue with few or no calcsilicate minerals. Such deposits are found within the granitic batholith as irregular pods or fissure veins, most commonly in migmatized areas where granitization or assimilation of the invaded metasedimentary rocks has been almost complete. These deposits are often along fine-grained dikes more mafic in composition than the surrounding granodiorite. These dikes, many of them schistose, may represent recrystallized metasediments which are incompletely assimilated. The third and least important mineralogic type consists of a minor amount of scheelite with base metal sulfides in limestone replacement or contact deposits. Deposits of base-metal sulfides with associated scheelite

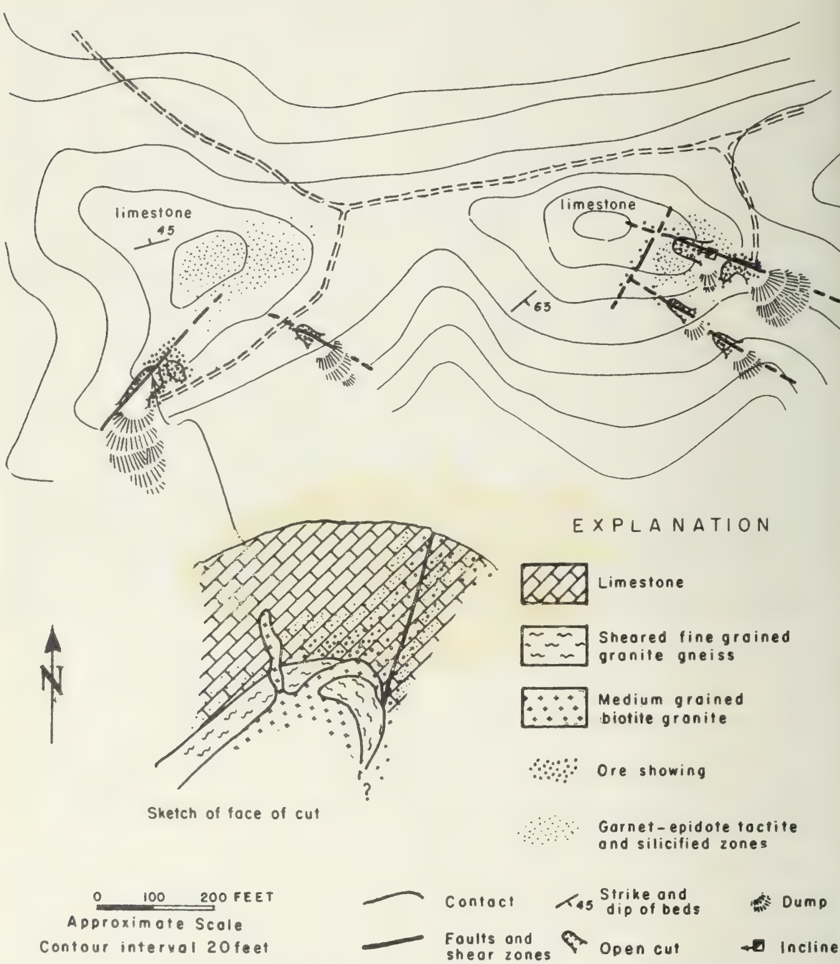

Figure 7. Map of Baker tungsten lease, and sketch of face of cut.

are found in the Camp Wishon district on the North Fork of the Middle Fork of the Tule River and have also been reported from the Mineral King district.

Baker Lease. Location: NW¼ section 30, T. 18 S., R. 28 E., M.D., in the Kaweah quadrangle about 5 airline miles southeast of Lemon Cove. Reached via Dry Creek road and the Powell Ranch. Ownership: Mr. H. Baker, Woodlake. Leased by Kaweah Mining & Milling Company, Box 59, Lemon Cove (1954-55).

The Baker Lease was operated from February to September 1954 and produced several hundred tons of high-grade ore. Scheelite, disseminated and in pockets, was found along shear zones and fractures in silicated limestone, particularly in folds (or rolls) between sheared

granite and limestone. Two prominent sets of fractures are mineralized. One strikes N 60° to 70° W., the other N 40° E. The limestone in general strikes N 50° to 75° E. Quartz veins and general silicification are more prominent than silication of the limestone in the vicinity of ore; however, large masses of barren garnet-epidote tactite are present in the area. Scheelite and quartz appear to have been introduced at the same time. No sulfides have been noted, and iron staining is not prominent.

The property was under development during the summer of 1954. Six large open cuts and one shallow inclined shaft comprise the principal workings. Ore was hauled 13½ miles to the company's mill at Terminus Beach. The grade of the ore recovered from development work ranged from 0.5 to 1.5 percent WO_3. No ore was blocked out at the time of visit; however, good showings were being developed at four different locations. Development work was suspended about September 1954.

Bill Waley Indian Allotment (J. H. B., Tom Cat). Location: SW¼ section 2, T. 15 S., R. 26 E., M.D., in the Dunlap quadrangle 1½ miles north of Consolidated Tungsten in Drum Valley. Reached via half a mile of dirt road north from the south end of Drum Valley. Elevation 2000 feet. Ownership: Indian land, leased to Wheeler Mining Company, 209 East Yosemite, Madera (1954).

Scheelite is found disseminated in garnet gangue and as large crystals in epidote gangue along the southwest border of a limestone pendant in granodiorite. The pendant is about 800 feet long and 40 feet wide, trends east, and dips steeply to the north. The entire eastern end of the pendant is replaced by tactite almost barren of scheelite. A zone 200 feet long by 20 feet wide, extending from the western extremity along the south edge of the pendant, is also silicated and is sparsely mineralized. The tactite zones dip north and are conformable to the bedding in the marbleized limestone. Several open cuts and shallow shafts on the southwestern edge of the pendant developed a zone of 1 percent ore about 3 feet wide and 75 feet long.

During 1943-44 some ore was shipped to the Tulare County mill and to Metals Reserve Company at Fresno. The property was active again during 1954, and ore was milled at the nearby Consolidated mill. Some development work was done by Consolidated Tungsten in April 1956.

Bob Marshall. Location: section 12, T. 21 S., R. 29 E., M.D., in the Kaweah quadrangle 1½ miles southeast of Springville, about half a mile northwest of Herbert and Crabb tungsten mine on the Vernon Gill Ranch. Ownership: Vernon Gill, Springville. Lessee, Bob Marshall, Springville, California (1954).

Sporadic deposits of scheelite along a fault in granodiorite were being prospected by surface development during 1954. No production has resulted. It appears likely that this zone is a continuation of the same fault along which ore occurs at the Herbert and Crabb mine.

Blossom Peak. Location: SE¼SE¼ section 25, T. 17 S., R. 28 E., M.D., in the Kaweah quadrangle, 3 miles by road southeast of Three Rivers. Reached via South Fork road. Ownership: Alles and Beam Ranch; leased to Three Rivers Mining Corporation (1954).

The mine workings are entirely within medium- to coarse-grained biotite-hornblende granodiorite which is cut by ramifying veinlets of quartz and small aplite dikes. Coarsely crystalline calcite and garnet-epidote tactite are found as brecciated fragments along to 2- to 5-foot shear zone which strikes N. 18° W. to N. 30° W., and dips 80° W. to vertical. Rounded fragments of tactite up to about 2 feet in diameter were observed in the fault gouge. A horse of crystalline calcite weighing about 5 tons is exposed along the shear zone. Scheelite is in the tactite fragments and in the green clay gouge surrounding them. Narrow veinlets of pure scheelite up to 2 inches in width cut both the granite and gouge along the fault. No scheelite was seen in the calcite horse. Limestone crops out over the entire hill behind the mine. The distance on the surface from the mineralized shear zone to the nearest point of contact with the limestone is about 300 feet to the northwest. An aplite dike about 18 inches wide, striking N. 45° E., dipping very gently to the north, overlies the deposit. The shear zone does not appear to cut the dike.

Two slot-stopes and an adit have developed the shear zone beneath the aplite dike. The upper slot-stope is 10 feet high by 6 feet wide by 30 feet long, immediately below the aplite dike. About 20 feet vertically below, an adit has been driven N. 30° W. for 60 feet. A second slot-stope, in 20 feet, has been driven immediately above the adit. The adit was the last scene of activity and developed about 30 feet of backs, less what had been removed in the slot-stopes. At the working face the gouge zone is 4 feet wide and contains an estimated 0.75 percent WO_3.

Some ore was milled at the Tulare mill during 1954. The mine was inactive in April 1956.

PHOTO 15. View of Consolidated tungsten mine, Drum Valley. *Photo by Mary Hill.*

PHOTO 16. Limestone body at Consolidated tungsten mine, Drum Valley. In the foreground a loader may be seen removing residual soil and broken ground.

Consolidated Tungsten (Drum Valley, Harrel Hill). Location: N½ section 11, T. 15 S., R. 26 E., M.D., in the Dunlap quadrangle, 1½ miles south of the Fresno County line at the southeast end of Drum Valley. Reached by dirt road half a mile south of Drum Valley road. Ownership: Consolidated Tungsten Milling & Mining Co., Mr. Claud Rouch, 14500 East Mountain View, Kingsburg, California.

The Consolidated Tungsten mine has been one of the most productive in the county. From 1942 through 1955 the mine was the source of 33,000 units of WO_3.

A north-trending elongate body of limestone and quartz-mica schist is enclosed in coarse-grained granite, which is deeply weathered in the mine area. Garnet-epidote tactite has developed along the contact and especially near the south end of the limestone mass. Scheelite is found throughout the tactite zone, especially in highly silicified zones. A large volume of residual soil overlying the tactite contains scheelite and in some places has proved to be ore. These deposits are near the crest of a small hill, and scheelite has survived to be concentrated in a placer deposit in Drum Valley to the northwest.

The main workings are a large glory hole, open pit, a haulage adit below the glory hole, an inclined shaft, and a surface placer operation below the mine workings in the southeast end of Drum Valley. A 50-foot adit, driven about N. 40° W. and a 20-foot incline driven 60° SW from the end of the adit failed to disclose any significant mineralization on the east side of the hill. These workings are in quartz-mica schist. About 80 feet vertically below the main workings on the northwest side of the hill, an exploratory adit driven southeastward 60 feet through massive limestone, failed to develop any ore below and to the

PHOTO 17. Haulage adit to glory hole and open pit, Consolidated tungsten mine, Drum Valley.

north of the main ore body. The underground workings shown by Krauskopf (1953, pp. 14-16) have now been largely removed by open-pit mining and by drawing of ore from a glory hole in the open pit. During 1954 ore was being drawn from the glory hole via a haulage adit. Open-pit mining of residual soil and broken ground on the edges of the glory hole was supplying the bulk of the ore to the mill.

The production of scheelite concentrates at Consolidated was supplemented by production from a placer operation on the slope below the mine workings during 1956. Placer scheelite in the residual soil has been known for some time. The maximum depth of the placer material is not known; however, it probably does not exceed 10 feet and is spread over an area of about 5 acres. The bedrock is predominantly decomposed granite, which makes recovery of the placer material easy.

The residual material contains from 0.3 to 0.5 percent WO_3. The placer in the valley below is reported to average about 0.5 percent. Select ore mined from the glory hole area by former operators contained from 2 to 10 percent WO_3.

Ore from the glory-hole operations was hauled by truck 2½ miles to the Consolidated mill. The residual and placer material was treated in the mine area. A bulldozer is used to scrape up the soil and transport it to a grizzly bunker. The soil passes through a grizzly onto a conveyor belt which feeds the trommel. Material larger than $\frac{5}{16}$-inch passes through the trommel and is stacked in a bin by a second conveyor. This over-size material is taken from the bin and stored nearby in open piles. Some scheelite is still contained in the oversize, and plans are to later crush this material at the nearby Consolidated mill. Scheelite is recovered from the minus-$\frac{5}{16}$-inch material in jigs and on concentrating tables; coarser scheelite, comprising about 60 percent of the total scheelite, is recovered in the first jig and the remainder recovered as a table concentrate containing about 20 percent WO_3. This is dried and canned and cleaned later by magnetic separation. The capacity of the plant is 20 tons per hour. Production is estimated at about 100 units per day.

The Consolidated mill is located in the north-central part of section 24, T. 25 S., R. 26 E., on Slickrock Creek a quarter of a mile north of its confluence with Murray Creek. Ore is hauled 2½ miles by paved road, downgrade, from the mine. Trucks dump ore over a grizzly into a coarse-ore bin. An 8- by 15-inch Pacific jawcrusher reduces the bulk ore after which it is elevated to a fine-ore bin. The fine-ore bin discharges to a vibrating screen (7-mesh on placer material and residual soil, 10-mesh on hard rock), and the fines bypass the ball mill. Ballmill discharge is through a 9-mesh outlet. Pulp is classified in a three-unit rectangular classifier of special design. Three classifications are made and tabled separately. Middling returns to the ball mill, tailing is elevated and discharged to the tailing pond. Concentrates go to the drying room where they are canned. An oil-fired hot plate is used to dry the concentrates. Concentrates requiring magnetic separation were formerly shipped to Twining Laboratory in Fresno for cleaning, but during 1954 a magnetic separator was purchased by Consolidated. Capacity of the mill is 60 tons during two 10-hour shifts. Some custom milling was being done in 1956.

Credow Mountain Tungsten. Location: S½SW¼ section 17, T. 23 S., R. 29 E., M.D., in the White River quadrangle at the southeast end of Credow Mountain 3 miles northeast of Fountain Springs. Reached via several dirt roads from the Fountain Springs-California Hot Springs road. Ownership: W. O. Dennis Ranch. Mineral rights leased to Mr. Schrader and Mr. Nolan, c/o Paul Morris Ranch, R.F.D., Fountain Springs.

The Credow Mountain tungsten mine has been operated intermittently since 1951 and by the end of 1955 had produced an estimated 752 units of contained WO_3.

Scheelite is disseminated in a garnet tactite at the extremity of a crystalline limestone lens which is in fault contact with granodiorite on the southwest side. The limestone forms a small part of a metamorphic pendant composed predominantly of quartz-hornblende-diopside schist, some of which is highly silicified. The pendant has a maximum width of 2500 feet and trends N. 70° W. along the southwest flank of Credow Mountain. Dips are near vertical with overturning (or drag folding) along the fault contact with granodiorite which forms the sub-

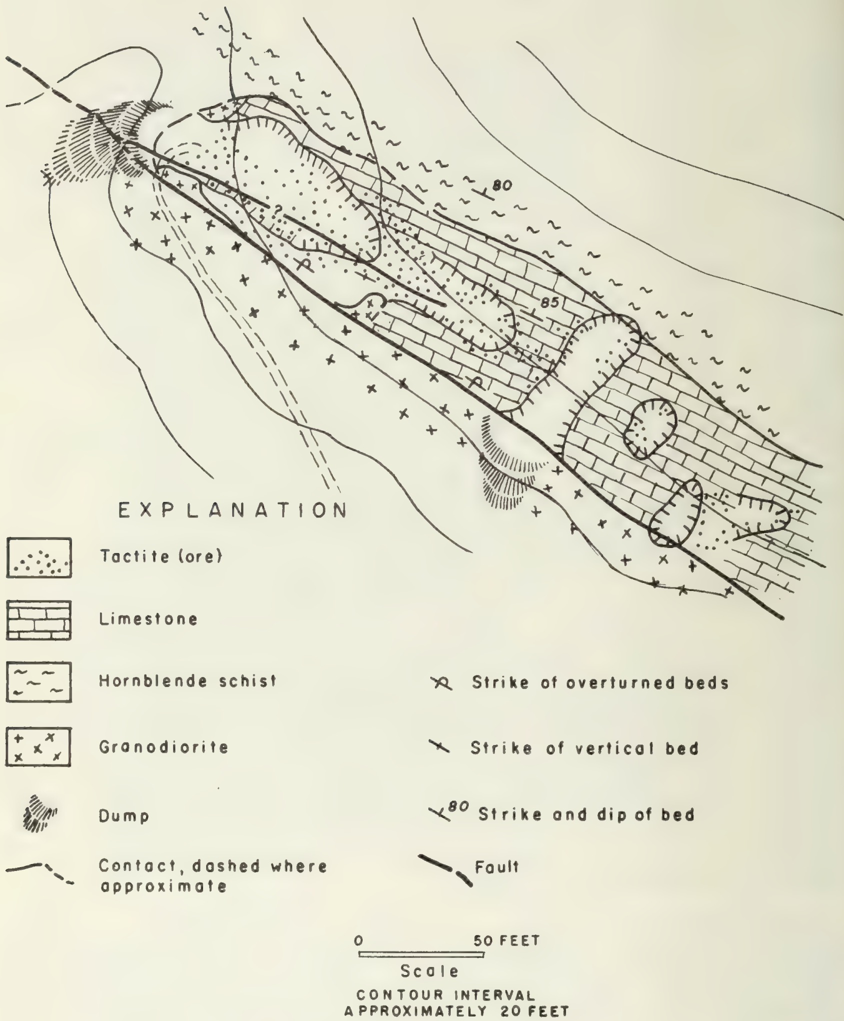

FIGURE 8. Geologic map of Credow Mountain tungsten mine area.

dued topography to the south. Several large quartz veins paralleling the schistosity crop out above the mine area. Credow Mountain proper is composed of a dark, fine-grained norite which crops out in bold rectangular blocks. Ore is related to faulting and localized beneath drag folds or overturning adjacent to the fault. The tactite is composed almost entirely of garnet and iron oxides. Epidote is inconspicuous except for a few small, fine-grained masses. Several minor cross-faults appear to have induced garnetization, and along one of these, minor copper staining is evident.

Six open cuts have explored the northwest end of the limestone pod. The main production has come from the two largest cuts at the ex-

tremity of the limestone pod. The grade of ore mined has averaged between 0.3 percent and 0.4 percent WO_3.

A considerable tonnage of low-grade ore is in sight. The maximum depth of the largest pit is only 20 feet, the adjacent cut only 10 feet. The intervening 10-foot bench was being mined during 1954. The ore appears to continue in depth and to plunge steeply to the northeast.

Herbert and Crabb (Gill Ranch). Location SW¼ section 12, and extreme NW¼ section 13, T. 21 S., R. 29 E., M.D., in the Kaweah quadrangle, 2 miles south of Springville at an elevation of 1200 feet. Ownership: Vernon Gill, Springville.

Ore was last produced from the Herbert and Crabb property in 1943 by Fred J. Herbert of Springville, who bought out his former partner I. S. Crabb of Los Angeles. The mine and mill were then operated for a time under the name *Herbert Mines*. The mill has subsequently been sold, but has not been removed from the property. Some development work was done by Messrs. Wheeler and Egley of Woodlake during 1954.

Scheelite was found in a large brecciated horse of silicated limestone in a fault zone and in gouge along the main fault in granodiorite. The principal mass of the horse was about 80 feet long, 4 feet in maximum width, and in the vertical dimension ranged from 8 to 50 feet. The deposit was explored by a 74-foot vertical shaft (flooded to within 40 feet of the collar in early 1956) and about 120 feet of lateral workings. Total estimated production is 225 units of WO_3, which was recovered from ore that ranged in grade from 0.5 to 1.0 percent WO_3.

In 1954, the lessees drove an adit in granodiorite about 125 feet northwest of the old workings. The heading of the adit is N. 70° E. and it was designed to cut the vertical fault zone, which strikes N. 20° W., at about 100 feet from the portal, thus developing about 40 or 50 feet of backs on the fault zone. Very little known ore was left by the former operator, except for a thin shell along broken ground where dilution and need for timbering made extraction marginal.

The property was inactive in April of 1956.

Homer Ranch. Location: NE¼ section 17, section 19, and W½ section 20, T. 16 S., R. 28 E., M.D., in the Tehipite quadrangle 6 miles south of Eshom Valley. Reached via Forest Service road from Eshom Valley. Ownership: Mr. T. Homes, Dry Creek Road, via Woodlake, California. Leased to Kaweah Mining and Milling Company, Box 59, Lemon Cove (1954-55). Lease embraced all of the Homer Ranch property.

Scheelite has been known in this area since World War II; however, no production has resulted and little development work has been done. The property was leased (1942-43) by Chase and Lineburger (Standard Tungsten Company). Kaweah Mining and Milling Company took a lease on the property in August 1954 and began prospecting. Trenches and test holes were enlarged and crosscut with a bulldozer. Favorable prospects were developed in sections 17, 19, and 20. Some road construction was necessary. Scheelite and gold were recovered in the Kaweah Company's mill at Terminus Beach.

During the latter part of 1954, efforts were concentrated on a newly discovered prospect in NE¼ section 17. Here scheelite is associated with

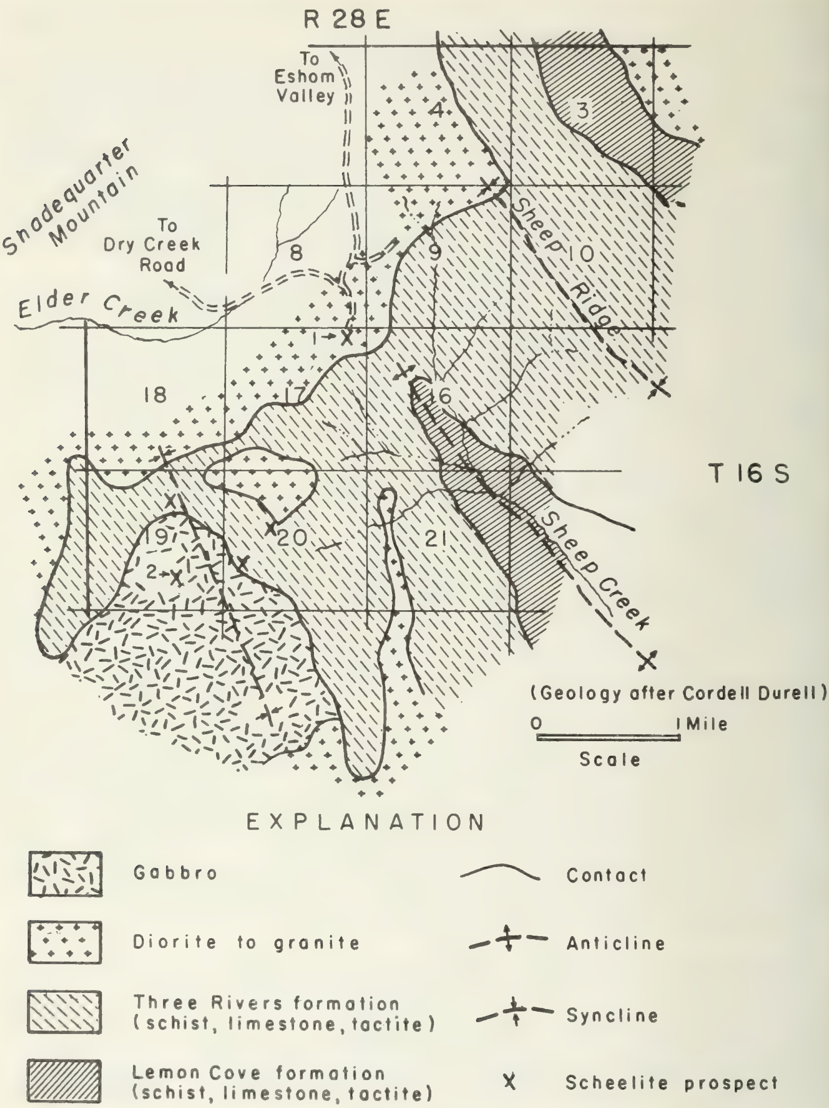

FIGURE 9. Geologic map of Homer Ranch tungsten mine area.

gold in quartz veins in granodiorite. The veins contain glassy quartz with some epidote and manganese oxides. Gold and coarsely crystalline scheelite occur along portions of the quartz veins which show several periods of fracturing and shearing. Adjacent to these veins is a 10- to 25-foot zone of brecciated, recemented garnet-epidote tactite; the zone trends northwest and dips 63° E. The most persistent quartz veins (12 to 14 inches wide) lie along the north side of this zone and parallel it; they dip 73° E. This zone and the quartz veins appear to be cut off on the northwest by a shear zone and on the east end by a

nearly vertical fault; these should converge about 60 feet northeast from the workings. The total horizontal extent of the brecciated tactite appears to be about 40 feet and may wedge out to the north and northeast between the converging faults.

The fault on the east side appears to be pre-mineral, and to have a curved surface convex downward. Mineralization appears to have been confined by this surface. The fault zone, which is at least 15 feet wide, appears to cut off the brecciated tactite on the northwest, and so may be entirely post-mineral.

The tactite breccia zone is loosely filled with large blocks of scheelite-bearing tactite, completely incoherent and with numerous voids. The pit exploring this zone has a maximum depth of about 30 feet at its northwest extremity and an average depth of 20 feet. A vertical 8-foot shaft in the east end of the pit explored the extension of ore in depth. An adit was driven from the east to cut the dipping ore zone at about 50 feet below the suface. This adit also was designed to explore a large area of barren tactite breccia down-slope to the east. The adit had been driven 50 feet by late 1954 and had passed beneath the tactite breccia into massive granodiorite, proving the mass to be entirely detached and probably of landslide origin. The sole of the landslide is separated from undisturbed granodiorite by a few inches of red clay.

About 450 tons of ore were mined and hauled 29 miles to the company's mill at Terminus Beach. The tenor of this ore was estimated to be 0.5 percent WO_3.

A prospect in the south half of section 19 was indicated on the surface by the presence of scheelite in the soil in an area mapped as gabbro (Durrell 1940). A 20-foot trench 3 feet wide and 3 feet deep exposed a tactite zone 15 feet wide. A bulldozer cut 20 feet south exposed only 5 feet of tactite near the surface. Within 10 feet of depth the tactite pinches out along a shear zone. This body appears to be the keel of an eroded pendant.

No work was in progress in April 1956.

Johnson Tungsten Mill. Location: SW¼NW¼ section 30, T. 21 S., R. 29 E., M.D., in the Kaweah quadrangle on the north bank of the South Fork Tule River, half a mile south of paved road in Success Valley. Ownership: Mr. Johnson, Success Valley.

Mr. Johnson operated the mill intermittently to handle ore from the Johnson prospect in the northeast corner of the Tule Reservation, about 20 miles from the mill. Ore is dumped over a grizzly into the coarse-ore bin. A chute delivers the ore by gravity to the primary jaw-crusher. Crushed ore is raised by bucket elevator to the fine-ore bin which discharges over a stationary quarter-inch wet screen. Undersize bypasses the secondary jaw-crusher and passes to a sump where it is joined by the recrushed oversize. A second bucket elevator lifts the pulp to a double-deck vibrating screen equipped with an 8-mesh and a 30-mesh deck. The minus 8 plus 30 mesh pulp flows to a cone classifier, the overflow of which goes to a second cone. The coarse fraction goes to a Deister table. The minus 30 mesh pulp from the vibrating screen goes to the second cone. The coarse fraction from this cone is fed to a Dunham table; the overflow returns to the pulp sump, the water being used in the double-deck screen. No middling is cut. The grade of concentrate is not known. No arrangement for fine grinding was made, so

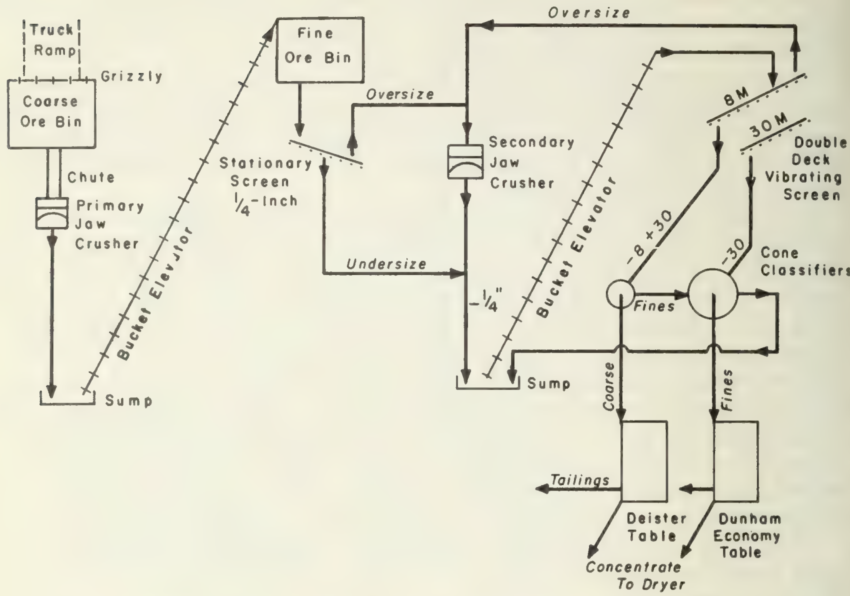

FIGURE 10. Flowsheet of Johnson tungsten mill in Success Valley.

PHOTO 18. Custom tungsten mill, Terminus Beach, northeast of Lemon Cove. Photo taken in 1955; the mill has since been dismantled and removed. *Reprinted from October 1955 California Journal of Mines and Geology.*

loss of scheelite mechanically combined with gangue probably was large.

Kaweah Mining & Milling Co. Tungsten Mill. Location: NE¼ section 35, T. 17 S., R. 27 E., M.D., at old gravel pit at Terminus Beach, 2 miles northeast of Lemon Cove in the Woodlake quadrangle. Ownership: Kaweah Mining & Milling Co., Box 59, Lemon Cove.

The mill began operating in February 1954 on ore from the Baker Lease; some custom milling was also done. Capacity was rated at 50 tons; however, the rod mill had a capacity of 120 tons. Five Dunham Economy tables were in operation. The cost of milling is estimated to have been $4.00 per ton. The custom milling charge was $12.00 in small lots, slightly less (by arrangement) in large lots.

Ore was passed through a primary jaw-crusher into a cone-shaped fine-ore bin, then ground in a rod-mill. The rod-mill product was discharged through an 8-mesh screen to a trommel for screening at 30-

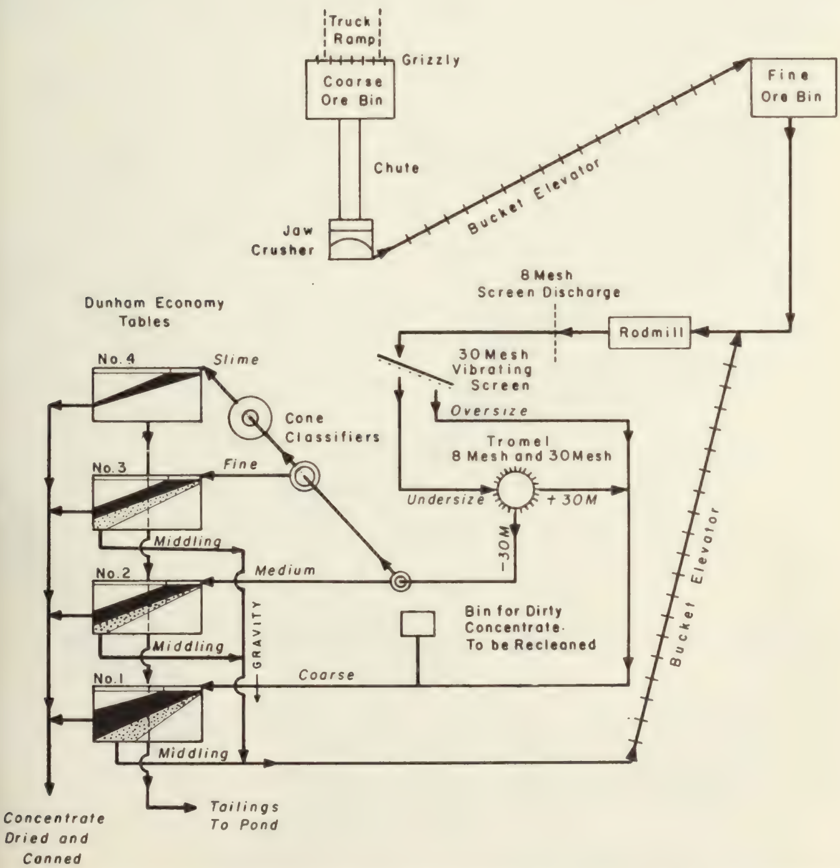

Figure 11. Flowsheet of Kaweah Mining and Milling Company mill at Terminus Beach.

mesh. All plus 30-mesh pulp was sent to the first concentrating table. The trommel undersize product went through a series of three cone classifiers, which divided the pulp into medium, fine, and slime products that were tabled separately. Middling was reground in the rod-mill. Tailing was transported, hydraulically, to the nearby gravel pit. Magnets were suspended above the tables over the concentrate band, and as magnetite particles moved into the field of the magnets, they were lifted slightly and wash water swept them into the tailing. Recovery of scheelite was stated to be about 85 percent. The greatest loss was on the slime

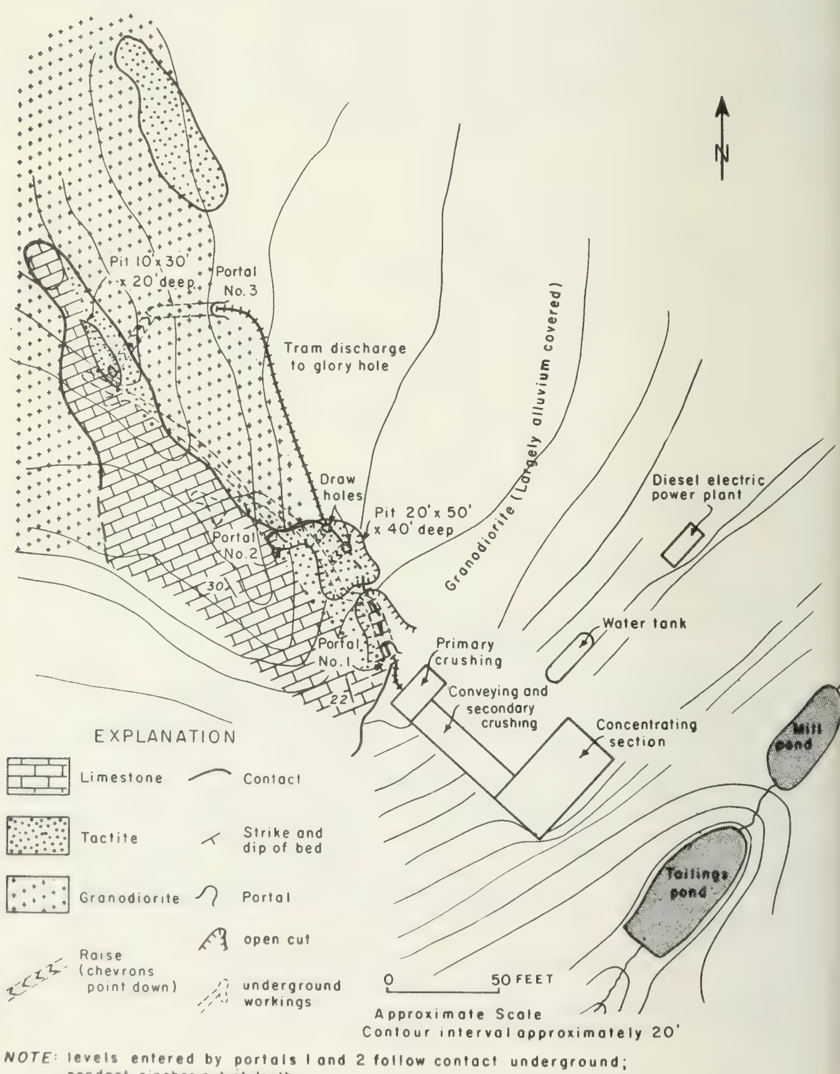

FIGURE 12. Geologic map of Pioneer (Goodhope) tungsten mine area.

table. Concentrates were dried over an oil burner and canned. Concentrates requiring further cleaning by magnetic separation were shipped to the Twining Laboratory in Fresno.

Amalgamation plates were added to the flow sheet to recover gold contained in the Homer Ranch ore. Only custom milling was being done in the spring of 1956 and the mill was subsequently dismantled and moved to Indian Wells in Kern County.

Pioneer (Goodhope) Mine. Location: SE¼ section 27, T. 18 S., R. 29 E., M.D., projected, in the Kaweah quadrangle 1 mile northeast of Grouse Valley. Reached from Three Rivers via South Fork road. Ownership: Goodhope Mining Company, J. H. Loughend, 120 "O" Street, Fresno. Leased to Mr. Levi Pettinger, P. O. Box 37, Three Rivers.

Scheelite is disseminated in garnet-epidote tactite along the northern edge of an irregularly shaped limestone pendant. The limestone is massively bedded, strikes N. 10° to 35° W., dips 22° to 30° S., and is in contact with medium-grained hornblende-biotite granodiorite. The greatest dimension of this pendant is about 300 feet in a northwest direction. Tactite was observed only along the northern contact and especially on the under side of the pendant, in the underground work-

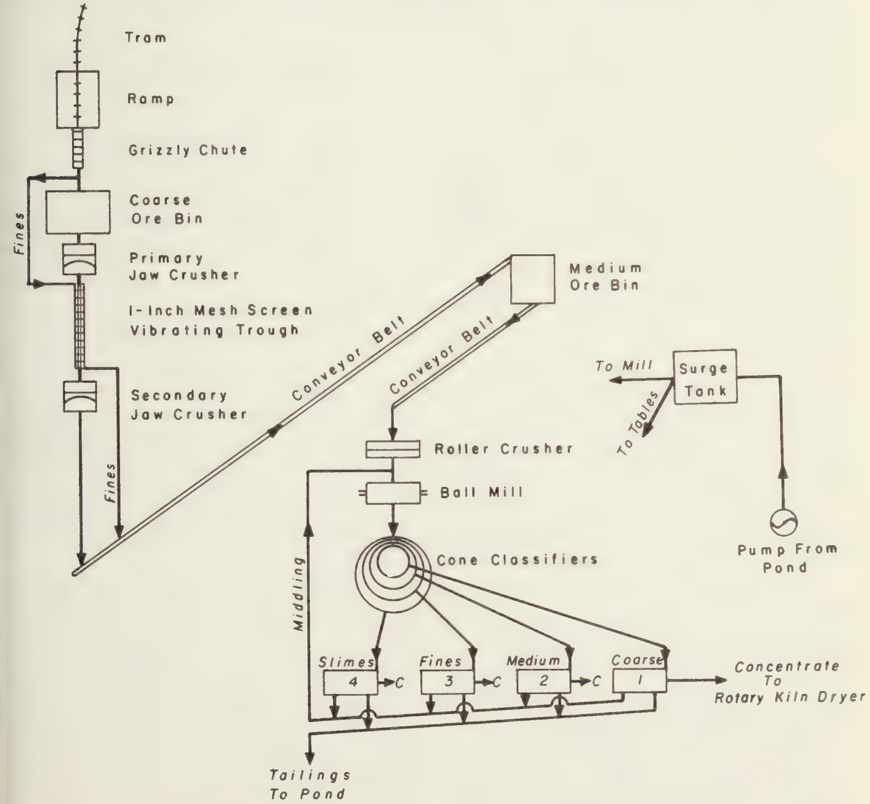

FIGURE 13. Flowsheet of mill at Pioneer (Goodhope) tungsten mine.

ings. The contact shows evidence of shearing at several points underground. Slivers of fine-grained schistose hornblende-quartz diorite are found at places along the sheared contact. This rock probably represents a border phase of the same intrusive where assimilation of the invaded metasedimentary rock is incomplete. A small metamorphic body completely silicated lies just north of the limestone pendant and is completely surrounded by granodiorite. This body is about 75 feet long and 25 feet wide. The trend of its axis conforms to that of the nearby limestone pendant. This body is roughly divided longitudinally into two mineralogical assemblages with a garnet-epidote tactite on the northeast side and diopside-wollastonite rock on the southwest side. No shearing is visible along the margins of this body, and no scheelite was observed.

The mine workings consist principally of two exploratory adits, one crosscut access adit, two glory holes, an open cut, and stopes connected to the exploratory adits by raises. Ore is trammed from the upper workings and dumped into a glory hole from where it is drawn off on the main haulage level. A tramway from the main level runs to a grizzly chute over the coarse-ore bin at the mill on the property. The mill had a rated capacity of 50 tons per day and utilized tables for gravity concentration. The mill was idle and being repaired early in 1956. Little or no custom work was done at this mill because of its inaccessible location.

The property was active from 1949 through 1955 and was the source of an estimated 1000 units of WO_3.

Schrader-Nolan Tungsten Mill. Location: Southeast corner of the SE¼NE¼ section 3, T. 24 S., R. 29 E., M.D., on Coko Creek in the White River quadrangle, on the Paul Morris Ranch, about 6 miles east of Fountain Springs. Ownership: Mr. Schrader and Mr. Nolan. The millsite is leased from Mr. Paul Morris, R.F.D., Fountain Springs.

The mill has been operating intermittently since 1951. The estimated production through 1955, exclusive of custom milling, was 752 units, all of which came from the Credow Mountain deposit about 6½ miles away. The mill is operated on a 10-hour shift by two men. Capacity is from 1 to 1½ tons of ore per hour. During a 10-hour shift about 200 to 250 pounds of 30 to 35 percent WO_3 concentrate is produced. This material is sun-dried and hauled to Fresno for magnetic separation, that results in a cleaned material averaging 72 percent WO_3.

Some custom milling is done, and during 1954 small intermittent shipments from the Tyler Creek mine (Acker Lease) were milled. The custom milling charge is $9.00 to $10.00 per ton.

A dump truck discharges ore from a grizzly ramp into the coarse-ore bin. The ore passes through a jaw-crusher to a roller-crusher, and is discharged directly to a 30-mesh trommel where it is wet-screened at 30-mesh. Undersize material goes to the pulp sump, bypassing the ball-mill. Oversize pulp feeds directly to the ball-mill which is equipped with a 10-mesh discharge screen and discharges to the pulp sump. A bucket elevator delivers the entire pulp to a Richards hydraulic classifier. A coarse product (10 to 30 mesh) is separated and flows by gravity to a Dunham Economy table. The overflow from this classifier is further classified in two cones, producing a medium and a slime prod-

uct. The medium pulp is treated on a Deister table and the slime on a second Dunham table. Middling is cut on the coarse and medium pulp only. A sand pump returns the middling to a hydraulic classifier. The coarse fraction from this classifier returns to the ball-mill circuit via the 30-mesh trommel; the fine fraction of the middling flows to the pulp sump and returns to the classifier circuit with no further regrinding. Tailing flows by gravity to the tailing pond. Concentrates are sun-dried and canned for shipment to the Twining Laboratory's magnetic separator in Fresno.

Thanksgiving Claim. Location: NW¼ section 31, T. 19 S., R. 29 E., M. D., in the Kaweah quadrangle, on the north side of Yokohl Valley road, about 4¾ miles northwest of Milo, about 3½ miles east of turnoff to Tulare County mine and mill. Ownership: Will Gill Ranch; leased to Butcher, Doyle, and Conlee, Box 354, Exeter.

The deposit lies on the contact between coarse-grained hornblende-biotite granodiorite and silicated and silicified limestone. Scheelite is in small spuds or pea-sized grains sparsely scattered throughout the contact zone which contains hedenbergite with disseminated pyrrhotite. Neither garnet nor epidote was observed. The ore is extremely hard and fresh. A border zone of slightly sheared, fine-grained rock which appears to be either a basic phase of the granodiorite or a migmitized zone occurs along the contact. No other evidence of faulting or shearing was noted.

This prospect was first developed in April 1953 by an open cut about 50 feet north of the highway, also by several prospect pits and an open cut which is now caved. A shaft was being sunk about 20 feet north of the highway in June 1954.

Production is stated to be about 200 units from ore which has averaged 0.25 to 0.5 percent WO_3. The prospect was worked intermittently during 1954. Ore was hauled about three-quarters of a mile to the Thanksgiving mill, which has a rated capacity of about 10 tons per day. During 1955, the mill was available for custom milling at $12.00 per ton, as the mine could not supply sufficient ore to keep the mill operating at capacity.

Ore from trucks is dumped over a grizzly into the ore bin. The bin discharges through a shaking feeder to the jaw-crusher and into the fine-ore bin. From the fine-ore bin a second feeder delivers fine ore to a vibrating screen (14 mesh), where water is added. Oversize goes to a ball-mill, undersize goes to a Dunham Economy table. The ball-mill discharge goes to the same table. Middling is cut and returned to the head of the table by a small bucket elevator. The entire flow is gravity fed, except for this one elevator.

A very clean concentrate (68 percent WO_3) is made, and a large middling is cut and returned to the head of the table. As no classification is being used, and middling is not returned to the ball mill, recovery probably is not high. Scheelite still locked in minus 14 mesh fragments of gangue, as well as in many of the slime-sized particles, is lost. The mill was designed to handle Thanksgiving ore in which the scheelite is in scattered spuds about the size of a pea. On this type of ore, recovery is stated to be about 85 percent, and sliming is negligible since the ore is not over-ground. The operators were considering adding

a slime table and replacing the ball-mill by one of sufficient capacity to regrind the middling. This set-up would include a simple classifier to split the pulp into two size fractions.

Tulare County Tungsten (Big Jim) Mine. Location: NE¼ section 11, T. 19 S., R. 28 E., M.D., in the Kaweah quadrangle in the canyon east of Chickencoop Canyon. Reached via Yokohl Valley road. Elevation 2000 feet. Ownership: Will Gill Ranch; leased to Tulare County Tungsten Company, D. F. Lauricella, Box 361, Lindsay, California.

The Big Jim mine is one of the three largest sources of tungsten ore in Tulare County. It has been operated continuously since November 1942, and through May 1955 had produced ore containing a total of 40,831 units of WO_3 (Trengove 1956, p. 1).

Scheelite is disseminated along fractured zones within a large body of silicated limestone, part of a pendant that also contains quartzite and hornfels. The best ore, some of which contained as much as 10 percent WO_3 and averaged about 0.7 percent, was mined from an open

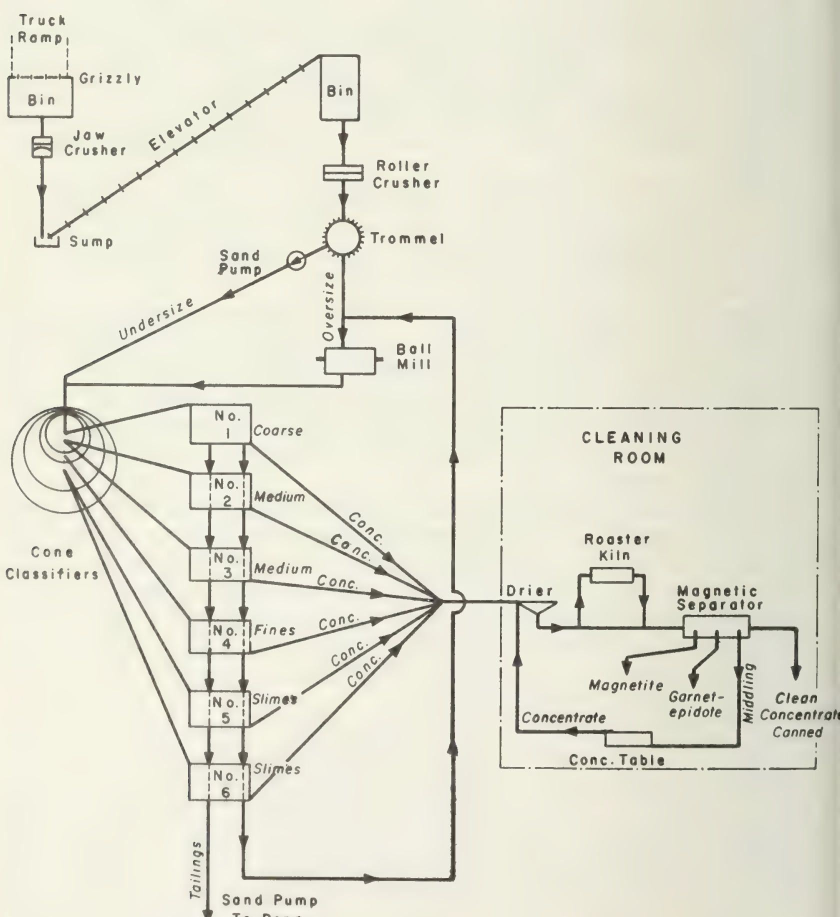

FIGURE 14. Flowsheet of mill of Tulare County Tungsten mine.

pit in a zone about 40 feet wide with granodiorite on either side. The principal gangue minerals in this zone were quartz, pyroxene, and calcite. This was part of a large tactite body composed essentially of garnet and epidote, much of which is almost barren of scheelite. Dips range from 80° W. to vertical.

The main ore body was mined from an open pit 60 by 80 feet by 100 feet in depth. The north and east walls of this pit are almost vertical and the west and south walls slope at about 45°. A 450-foot adit was driven north beneath the mineralized zone and about 150 feet lower in elevation than the rim of the open pit. This adit was used to stope the lower part of the main ore body, forming a glory hole. A winze to the 250-level gave access to the downward extension of the main ore shoot, about 100 feet northeast of the main pit or glory hole.

The tactite zone, about 80 feet wide, extends northeastward for an undetermined distance. In this area the tactite is composed essentially of garnet with minor epidote, pyroxene, and calcite; scheelite is finely disseminated as grains which fluoresce yellow. This northeasterly extension was being explored by an open cut which was being advanced northward into a steep hillside. The face of this large cut was over 50 feet high in late 1954. A large tonnage of low-grade ore is in sight and the northern extent of the body has not yet been determined. The grade of the ore is between 0.3 and 0.5 percent WO_3.

A crosscut from the 250-foot level in 1956 has found a new ore shoot which may connect with the main ore body that was being mined by open pit in 1954. A crosscut from the 150 level is planned to prove this ore shoot and cut it at an intermediate level.

Ore is hauled down a steep, winding grade to the Tulare County Tungsten Company mill, about a mile south in the N½ section 14. The mill has a rated capacity of 125 tons per day. Some custom milling is done; base charge is $12.00 to $15.00.

The ore is crushed, ground, and classified to six sizes, each of which is tabled separately. Two tables are fed material in the slime class. The highest grade concentrate is from the coarse table and is stated to assay about 30 percent WO_3. This table also produces the largest quantity of concentrate. No attempt is made to cut a high-grade, clean concentrate. Middling is returned to the ball-mill, tailing is pumped to a pond, and concentrate is taken to the cleaning room where it is dried and sent through three-crossbelt magnetic separator. Reject from the magnetic separator is tabled and the concentrate dried and returned to the magnetic separator. Concentrate containing sulfides is roasted prior to magnetic separation. Cleaned concentrate from the magnetic separator, assaying more than 60 percent WO_3, is canned for shipment.

Tungstore (Kennedy, Jack Ranch). Location: SE¼ section 32, T. 24 S., R. 31 E., M.D., in the Tobias Peak quadrangle near Posey. Elevation 4500 feet. Ownership: Tungstore Mines Company, C. A. Rasmussen and W. A. Trout.

The property, formerly known as the Kennedy Tungsten mine, was prospected as early as 1929 (Franke 30: 464-465) and in 1932 became the first source of tungsten in Tulare County. Operations were continu-

ous through 1942. Between 1942 and 1944, the tailings were reworked by two lessees, Krebs and Martin. The total production of the property is 48,162 units of WO_3. The average grade of ore mined was between 1 and 2 percent WO_3. The property has been idle since May 1944.

Scheelite is in a gangue of quartz, garnet, amphibole, and sulfide minerals, in irregular bodies within a group of small pendants in granodiorite. The pendants are composed of schist, quartzite, and limestone, trend northwestward and dip steeply to the northeast. The main ore zone was 170 feet long, 15 feet wide, and 80 feet in the vertical dimension. This zone had a northwest strike and dipped from 53° NE to vertical. Mine workings included an open cut 200 feet by 100 feet with a maximum depth of 80 feet. A cross-cut adit 420 feet long was driven beneath the main cut to develop downward extensions of the ore zone. Underground workings from this adit include 540 feet of drifts and crosscuts, and 160 feet of raises.

Tyler Creek (Bull Point, Verne Tyler). Location: N½ section 35, T. 23 S., R. 30 E., M.D., in the Tobias Peak quadrangle about 2 miles west of California Hot Springs, adjacent to and north of Deer Creek road. Elevation 2400 feet. Ownership: West Tyler workings owned by Mr. Lundeen, California Hot Springs, and Mrs. Rounsaville, Porterville. East Tyler workings owned by Verne Tyler, California Hot

PHOTO 19. Mill of the National Tungsten Corporation, Tyler Creek. *Photo by Scribner S. Kirk, courtesy National Tungsten Corporation.*

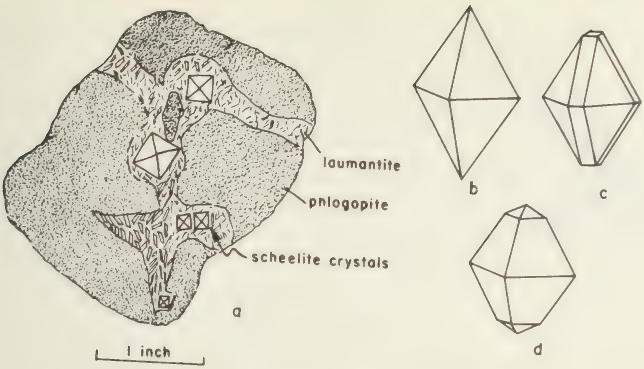

FIGURE 15. Scheelite crystals from Tyler Creek mine. (a) Crystal in matrix; (b) usual form of crystals; (c) and (d) forms seen on some crystals.

Springs. East and West workings were leased individually 1954-55, but now all are leased to National Tungsten Corporation, 148 North Main Street, Porterville, California.

The Tyler Creek tungsten mine has had four periods of operation: 1938-41, 1943-45, 1954-55, and 1955-57. During the period 1943-45, a 25-ton mill was built on the property, but after World War II the property became idle during litigation, and the mill was moved to Drum Valley. Prior to 1955 the total production was about 1000 units of WO_3.

Thin tactite layers have formed in limestone beds that are a part of a pendant of metamorphic rocks adjacent to granodiorite along a northeast-trending contact. Schist and quartzite comprise the rest of the pendant. All of the tactite explored lies at the southeast margin of the pendant, northwest of the contact.

Prior to operations of the National Tungsten Corporation, the property was developed by two open cuts, the larger about 100 feet by 20 feet by 20 feet, a 150-foot adit beneath the open cut, and several shallow shafts, all at the southeast margin of the pendant. About a quarter of a mile northeast along the eastern margin of the pendant some ore was developed by a 140-foot adit with appended workings and raises to an upper level. These workings were known as the West Tyler and East Tyler workings. Most of the production came from the open pit in the West Tyler workings.

The property was acquired in 1955 by National Tungsten Corporation. An adit was driven N. 65° E. beneath the West Tyler workings (now known as the Rounsaville workings). The adit had been driven 300 feet by January 1957, well beyond the earlier West Tyler workings. Ore was encountered in crosscuts and in drill holes at points along the northwest side of the adit. Three short raises to the northwest near the working face have blocked out the high-grade ore body in which the scheelite crystals are found. The working face of the adit is in soft, decomposed granodiorite cut by small quartz veins. The heading of the adit is toward the East Tyler workings where an open cut above the old workings has exposed a body of shattered

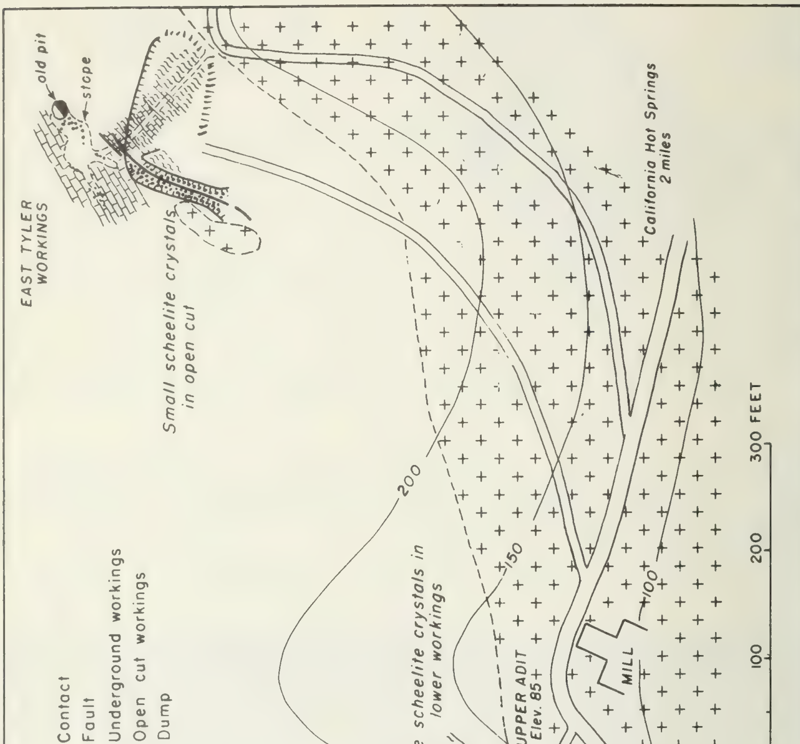

FIGURE 16. Sketch of the geology and workings, Tyler Creek tungsten mine, National Tungsten Corporation.

garnet tactite about 200 feet in length, 16 to 20 feet wide, and at least 40 feet in vertical dimension. This ore body trends N. 15° E. and dips 75° to 80° NW into the hillside.

Ore is milled at the property, and the mill heads were reported to average 0.66 percent WO_3. The grade of reserves in the mine is stated to range from 0.25 to 2.25 percent WO_3.

The deposit is unique for the occurrence of well-formed scheelite crystals that have been found underground. The crystals are in a zone of soft material about 3 feet wide in a body of hard, scheelite-bearing tactite about 18 feet wide, 60 feet in vertical dimension, and over 100 feet long. The tactite is composed largely of diopside, quartz, calcite, wollastonite, and some epidote and garnet; it lies at the contact between granodiorite and a metamorphic pendant composed of limestone, quartzite, and hornfels. The crystal-bearing zone is near the east edge of the tactite within 4 feet of the granodiorite contact along a sheared zone parallel to the contact. The contact and the ore body at this point trend approximately N. 50° E. and dip steeply northwest. The matrix in which the crystals are found is a fine-grained, slightly coherent mass of minute plates of greenish-brown phlogopite (a magnesium mica). The scheelite crystals are in the phlogopite along veinlets of crystalline laumontite (a calcium-sodium zeolite). The crystals are both simple and modified dipyramids and average about $\frac{7}{16}$ of an inch in maximum dimension. Most of them are clear and transparent; some contain inclusions of the matrix; some contain small inclusions of chlorite; and one was observed to contain a liquid-gas bubble.

Uranium and Thorium

Following the discovery of uranium near Miracle Hot Springs in Kern County, a large number of claims were staked in southern Tulare County. Areas from which radioactivity has been reported include the Needles area east of Quaking Aspen; Parker Creek area west of Johnsondale; Salmon Falls; Kern River Canyon north of Thunderbird Lodge; Pup Meadow east of Pine Flat; Balanced Rock; and Lamont Meadows and Long Valley, west of Nine Mile Canyon.

At most of the claims no uranium-bearing minerals were identified, as high background readings were caused by small amounts of monazite or allanite. Monazite (thorium-bearing phosphate of the cerium metals) is a fairly common accessory mineral in granite, and radioactivity from this source may be very misleading. Allanite (a rare-earth and thorium-bearing variety of epidote) is found chiefly in pegmatite dikes in the area. Though monazite and allanite contain minor proportions of thorium and occasionally of uranium, they are not of present commercial interest. Other uranium and thorium-bearing minerals which have been identified in Tulare County include xenotime, euxenite, torbernite, autunite, and uraninite. Though torbernite and autunite occur as alterations of uraninite and other primary uranium minerals, in Tulare County they are found chiefly in altered shear zones in granite where no definite link to primary mineralization is evident.

All known deposits containing uranium- and thorium-bearing minerals in Tulare County are of doubtful commercial interest.

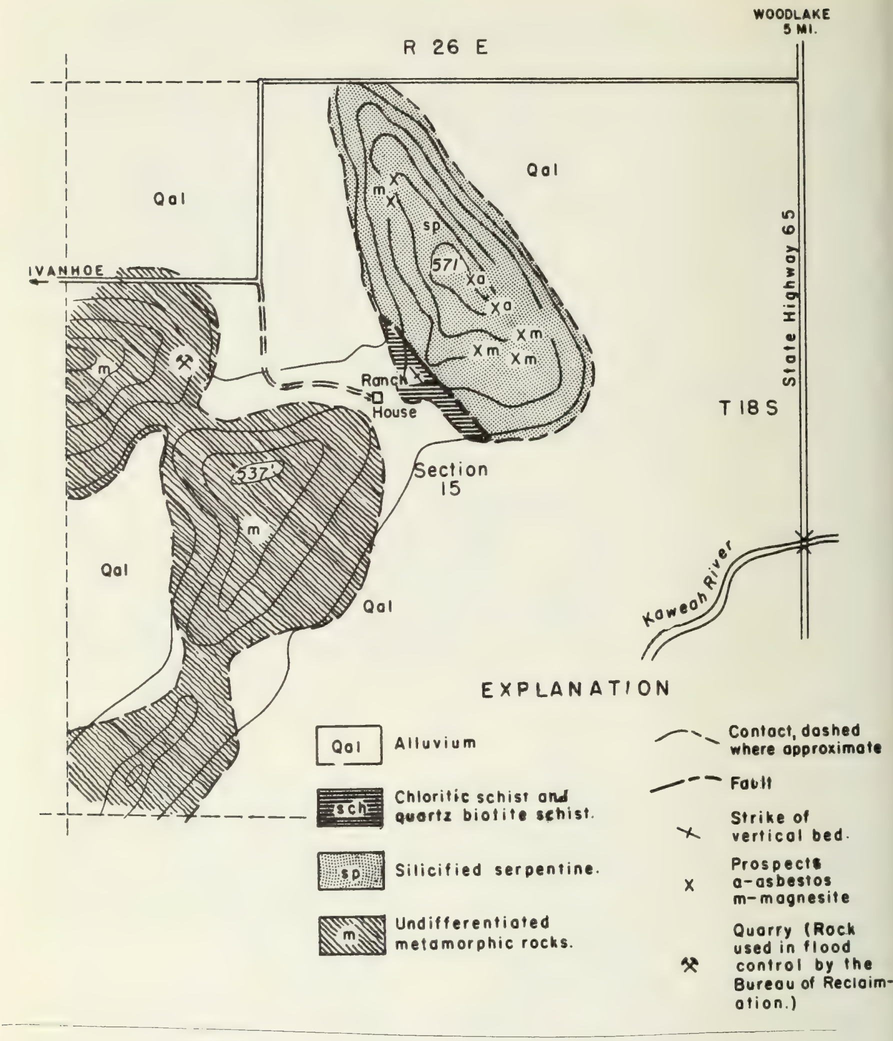

FIGURE 17. Geologic map of Hanggi Ranch asbestos and magnesite deposit.

Zinc-Lead-Silver

About 30 zinc-lead-silver prospects have been reported in Tulare County, but none of them has been developed beyond the prospect stage, and production is insignificant.

Sphalerite (zinc sulfide) and argentiferous galena (lead sulfide containing some silver) occur in metamorphosed sedimentary rocks, especially limestone, near contacts with intrusive granitic rocks. The common gangue minerals in such deposits are quartz, calcite, and a large variety of calc-silicate minerals. Sparse zinc-lead-silver mineralization is common in the Mineral King district and along the North Fork of the Middle Fork of the Tule River in the Camp Wishon district. The

relative inaccessibility of these areas has hindered development. Only one deposit, the Cedar Hill, has received any attention since 1930.

Nonmetals

Asbestos

Deposits of amphibole asbestos of doubtful commercial interest have been found in five localities along the foothills in Tulare County. These deposits are in narrow zones in fractured and serpentinized ultra-basic rocks.

Hanggi Ranch Deposit Location: N½ of section 15, T. 18 S., R. 26 E., M.D., on the easternmost hill in Venice Hills about 5 miles south of Woodlake in the extreme northeast corner of the Exeter quadrangle. Ownership: Mr. Morris Hanggi, 121 Burrel Avenue, Visalia.

Two prospect pits on the crest of the hill northwest of the ranch house expose zones of sheared amphibole asbestos in silicified serpentine. The pits are about 5 feet in diameter and 12 feet deep. Within this vertical range the maximum observed width of the asbestos zone is 4 feet. The lens-shaped bodies of amphibole appear to be discontinuous in both the vertical and horizontal plane. The maximum fiber length is about 6½ inches. The lenses are highly fractured and in part replaced by opal and quartz.

Five other prospect pits on this hill have exposed narrow veins of siliceous magnesite in the same serpentine body.

Barite

Barite ($BaSO_4$) has been found in four localities in Tulare County. It occurs in veins and replacement pods in metasedimentary rock. The first recorded production from Tulare County was in 1931.

Camp Nelson Barite. Location: SW¼ section 33, T. 20 S., R. 31 E., M.D., in the Kaweah quadrangle, about 1 mile southwest of Camp Nelson. Ownership: Mr. A. Montrose, 1008 3d Street, Porterville.

Barite occurs as residual remnants (spuds) and sand in a matrix of red clay terra rossa on the weathered surface of baritic limestone. The weathered zone is reported to have a maximum depth of 40 feet and to contain barite over an area of about 700 feet by 1200 feet. Baritic limestone appears to be only 2 feet thick in outcrop. It is underlain by siliceous limestone, quartzite, and black slate, and overlain by 25 feet or more of fetid limestone. The metasedimentary rocks strike N. 20° to 60° E., and dip 20° to 50° NW.

Mining has been confined to an area of about 2 acres. Weathered rock and soil is excavated by a bulldozer and scraper. The broken material is dumped over a vibrating screen which dislodges most of the adhering clay and soil. The barite that is recovered is mostly of lump size and has been shipped to Industrial Minerals, Inc., Oakland. The operator is producing from 5 to 10 tons per day. Plans are being made to trommel and jig the ore, thereby making a higher recovery as well as a cleaner product (Mr. Montrose, personal communication). Water is available from the nearby fork of the Tule River.

Paso-Baryta (Nine Mile Canyon Barite, Barite King). Location: Sections 34, 35, T. 23 S., R. 36 E., and section 2, T. 24 S., R. 36 E., M.D., in the Kernville quadrangle near Inyo County line. The deposit is reached via Nine Mile Canyon road from U.S. Highway 395 in Inyo County. Ownership: Claims are held by Jack Richards, San Fernando, and by Western Barium Corporation, San Francisco (1956).

Impure barite is found in a zone 10 to 15 feet wide over an outcrop length of about 1 mile. The zone strikes from N. 10° W. to N. 40° E., dips about 65° SW, and apparently is conformable to the attitude of the enclosing metasedimentary rocks. The northwest end of the deposit splits into three narrow branches.

Barite first was shipped from these deposits by the Paso-Baryta Mines, Ltd., in 1931 (Franke 1930, p. 431). During the early 1950s, several thousand tons of barite were mined from a small open pit and shipped to Oil Base, Inc., Long Beach. The undeveloped probable reserves are estimated to be large, although most of the barite will not meet gravity specifications for drilling mud, and require beneficiation.

In 1956 the deposits were re-opened by Macco Corporation. Barite was mined from an open pit and trucked to a new concentrating plant constructed at Linnie Station, Indian Wells Valley, Kern County. The plant was handling mine-run barite at the rate of 400 tons per day. Processed barite was transported from the concentrator to a blending plant at Rosamond, operated by the same company to produce drilling mud.

Clay and Clay Products

Alluvial clay, suitable for use in common brick, tile, and other wares made from red-burning clays, is plentiful throughout the western portion of the county. Clay is interbedded with sand and gravel in a thick accumulation of Cenozoic sediments along the major rivers and creeks and creeks west of the foothills.

Practically the entire production of clay in Tulare County has been used in the manufacturing of common bricks and minor amounts of tile. Production began about 1898 and reached a peak of 10,900 million bricks in 1912. Two plants, each with a capacity of 40,000 bricks per day, were operating. At present, annual production is about 2.5 million bricks.

Small amounts of fire-clay and other special-use clays have been produced and consumed locally.

S. P. Brick and Tile Company. Location: Section 3, T. 19 S., R. 26 E., M.D., on Belmont Avenue about half a mile northwest of Exeter, in the Exeter quadrangle. Ownership: S. P. Brick and Tile Company, 326 Parallel Avenue, Fresno.

The plant is situated on the Southern Pacific Railroad, which bounds the property on the south and east sides. The property is bounded on the west side by Belmont Avenue. Five Stewart & Clamp open kilns (oil-fired) are in operation. The plant capacity is 40,000 bricks per day; however, production is now limited to summer months with an average annual production of 2½ million bricks.

Alluvial clay is broken in a Scott-Madden pulverizer and screened. The screened material then goes to a pug machine and mud machine.

PHOTO 20. Plant of the S.P. Brick and Tile Company, Exeter. Pit to the left is ow exhausted and clay is brought from a pit at the other side of town. *Photo by Iary Hill.*

PHOTO 21. Locust Grove School, Exeter. The dark red brick of which the school constructed was made locally. *Photo by Mary Hill.*

The extruded clay is cut into bricks and stacked on pallets in the curing shed. The curing period is 15 days, after which the clay bricks are trammed to the kilns and loaded. Eight days of continuous firing are required to burn the bricks. The ends of the kilns are opened and the finished bricks are loaded onto pallets for shipment by truck or rail.

The deposit on which original pit was located, at the plant, has now been exhausted. Its dimensions are approximately 1300 feet by 300 to 500 feet by 20 to 40 feet. The clay is underlain by gravel which is now being used by the County Roads Department. Clay for brick manufacturing is being trucked from the excavation at the county dump on Belmont Avenue south of Exeter.

Feldspar

Small amounts of potash feldspar were produced in Tulare County between 1913 and 1920. The peak production was during 1914, when 2830 tons valued at $18,065 was mined. The total production was 6,743 tons valued at $29,123.

The entire production came from granite pegmatites in the Three Rivers, Lemon Cove, and Yokohl Valley areas. The pegmatites were mined by open cuts, and feldspar crystals were hand sorted to meet specifications. The value of feldspar at the mines was between $2.00 and $4.50 per ton.

Gem Materials

A large variety of minerals of interest to gem and mineral collectors is found in Tulare County. The most notable is chrysoprase, a variety of chalcedony which is tinted green by small amounts of nickel. Chrysoprase is found in silicified serpentine at five localities in Tulare County.

Chrysoprase was first discovered at Venice Hills near Ivanhoe in 1878 by Mr. George W. Smith (Aubury 1905, p. 171). Mr. C. P. Wilcomb of San Francisco later discovered the principal vein from which about 300 pounds was produced. Four major pits explored fractures containing chrysoprase and hydrous nickel silicates along a zone about 1000 feet long. The maximum width of veins was 2 to 3 inches. This deposit has been of more recent interest for its nickel content.

In 1879 chrysoprase was discovered southeast of Porterville on Tennessee Ridge by Mr. L. B. Hawkins. The following year a locality was discovered east of Lindsay (Chrysoprase and Todd Hills) and at Stokes Mountain east of Orosi.

The chrysoprase is in veins occupying joints and fractures in silicified and laterilized serpentine. Veins are 3 inches or less in width and grade laterally and vertically into soft bluish-green garnierite (hydrous silicate of nickel and magnesium).

The total production of gem-quality chrysoprase exceeds 3000 pounds. The last-known production was in 1932, and was made by Janoiko Brothers, Porterville.

Other gem materials found in Tulare County include quartz, rose quartz, onyx, rhodonite, nephrite, vesuvianite, several varieties of garnet, tourmaline, spinel, and opal (Murdoch and Webb 1948).

Deer Creek Chrysoprase. Location: SE¼ section 20 and the NE¼ section 29, T. 22 S., R. 28 E., M.D., on the southwest flank of a small hill at the extreme northwest end of Tennessee Ridge in the White River quadrangle. Ownership: Rube Shannon Ranch.

Chrysoprase was discovered here by L. B. Hawkins in 1897. The deposit is reported to have produced about 1200 pounds from veins

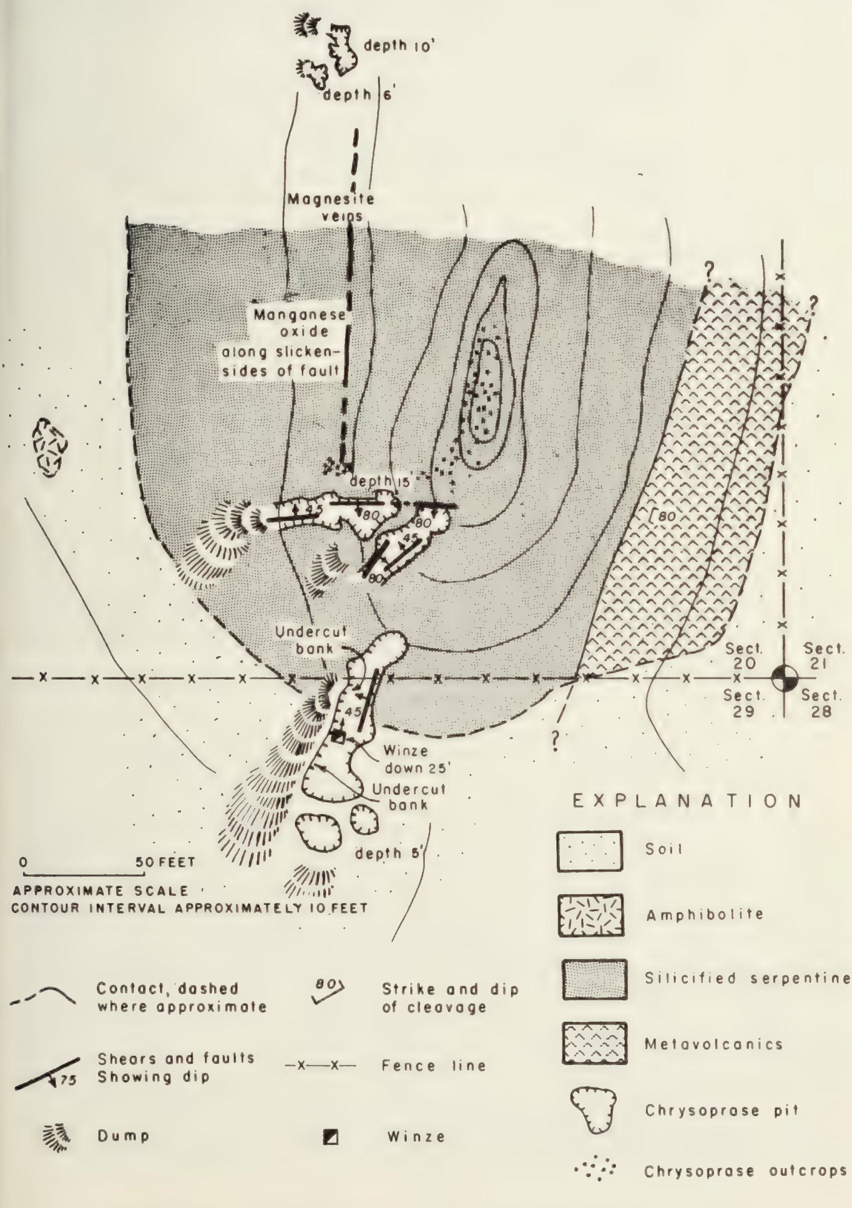

FIGURE 18. Geologic map of Deer Creek chrysoprase mine.

2 to 3 inches wide (Aubury, 1905, p. 74). The last known operator was T. T. Sullivan, Tulare, in 1916 (Tucker 1919, pp. 910-911).

The chrysoprase fills fractures in blocky, highly fractured silicified serpentine. Silicification is in the form of mottled opal and brown to red jasper. Such material caps the rugged peak of this small hill. Lower on the slope of the hill the serpentine is less altered and is cut by a few veins of magnesite. Metavolcanic rocks with a north trending schistosity and vertical dip crop out in a saddle at the southeast end of the hill. On the west flank hornblendite crops out in a small area; soil cover is heavy on the slopes.

The serpentine is highly fractured and it is along the fracture planes that chrysoprase was deposited. More or less garnierite is associated with the chrysoprase. The intimate association of chrysoprase and magnesite, and their joint association with garnierite indicate a probable supergene origin.

The deposit has been developed by three large pits and four small pits. The maximum depth of the pits is about 15 feet, the maximum length about 100 feet. The three major pits all have a near vertical to overhanging wall on their north and northwest sides and a 45° wall on their south and southeast sides. These planes are formed by fractures, some of which show shearing.

Very little chrysoprase is visible in the workings; however, much fragmental material is present in the dumps. Thin, irregular seams of chrysoprase crop out just north of the main workings and also on the crest of the hill.

Graphite

Commercial deposits of graphite have not been found in Tulare County; however, graphite has been reported in the vicinity of Camp Nelson, Drum Valley, and in the Lemon Cove and Dry Creek areas. Graphite occurs in pre-Cretaceous schists formed by the metamorphism of carbonaceous sedimentary rocks.

Limestone

Pendants of crystalline limestone of pre-Cretaceous age are found broadly distributed through the mountainous parts of Tulare County. However, many are remote from railroads and from highways engineered for heavy trucking, and many are found on rugged terrain adverse to low-cost quarrying. Tulare County is so situated, nearly midway between the principal marketing centers Los Angeles and San Francisco, that there has been little incentive for development of the very considerable limestone resources available.

The limestone masses generally are lenticular with long axes trending north or northwest. Common metamorphic rocks associated with the limestone are hornblende amphibolite, quartz-mica schist, and slate. Many pendants are cut by granitic intrusions and siliceous contact-metamorphic rocks are commonly developed along granitic rock-limestone contacts.

Three quarries have produced intermittently in the past, one each near Lindsay, Porterville, and Lemon Cove, but none of these developed masses of notable magnitude. The largest resources of limestone in the county are concentrated in the Three Rivers, Marble Fork, and Moorehouse Creek districts where individual deposits run into many

millions of tons. In the Three Rivers district large limestone masses are found in a north-trending belt extending from the vicinity of Blossom Peak on the south, up the North Fork of the Kaweah River for a distance of nearly 10 miles. None of these has been exploited, but some have been held for many years by Pacific Portland Cement Company and its successor, Ideal Cement Company. About 6 miles east of the Three Rivers district are several large masses of limestone grouped along the Marble Fork of the Kaweah River. Some of these are of comparable magnitude to those in the Three Rivers district, but they are somewhat farther from potential markets. The Moorehouse Creek district adjacent to the south fork of Tule River 12 miles east of Springville contains one immense mass of limestone more than 2500 feet wide and several miles long, but the terrain is very rugged and the 35-mile winding mountain road into Porterville is not well engineered for heavy trucking. Much of the limestone-bearing land is held by Riverside Cement Company.

Between 1896 and 1932 limestone production totaled 203,094 tons, valued at $685,594. The largest production came from the Kaweah quarry near Lemon Cove. During 1924 this quarry produced 24,000 tons of rock and about 30 men were employed. Most of the limestone was sold for agricultural use, but some was used as filler in asphalt road topping and in manufacture of concrete pipe.

The second largest recorded production came from the Lindsay quarry in the Oat Canyon district 7 miles east of Lindsay. Between 1925 and 1932 the quarry was operated to supply lime kilns and sugar refineries. About 10,000 tons of sugar-rock was marketed in the San Francisco Bay area between 1930 and 1932.

PHOTO 22. Site of Kaweah Lime Products Company installations at Terminus Beach, on Limekiln Hill near Lemon Cove. One of the pits can be seen in right center distance of photograph. *Photo by Mary Hill.*

PHOTO 23. Network of magnesite veins in brown jasperoidal serpentine. The rock shown here, in which the magnesite veins are an inch or less in width, is a boulder used as ballast in construction of the canal near Lindsay. *Photo by Mary Hill.*

The third largest recorded production came from the Worth quarry near Success, 6 miles southeast of Porterville, which operated intermittently up to 1925. The exceptionally high-quality, pure white, coarsely crystalline limestone was crushed for agricultural limestone or processed into lime.

Some development work, in the form of test adits, was done in the 1920s on the Holdridge deposit at the edge of Pleasant Valley 7 miles northeast of Porterville. This deposit is owned by Ideal Cement Company. None of the deposits in Tulare County were active in November 1957.

Magnesite

Prominent outcrops of white magnesite in the low, rolling foothills near Porterville were noted and described as early as 1853 by a survey and exploration party mapping the natural resources of lands along proposed railroad routes. It was not until 1900, however, that magnesite was mined in Tulare County. Annual production rose from an average of about 2500 tons during the early 1900s to a peak of 136,562 tons in 1917 when imports from Europe were curtailed. Tulare County magnesite deposits were of national significance during World War I, when they, and deposits in Washington, were the only domestic supply. During the peak period, about 28 individual deposits were being mined between the Deer Creek-Porterville area and Exeter. Monthly production during 1917 averaged 8110 tons of crude magnesite worth $12.50 per ton (Bradley, W.W., 1925, p. 103). Some of the material was calcined locally and some shipped to the San Francisco Bay area for

PHOTO 24. Outcrop of magnesite rock on Rocky Hill near Exeter. Magnesite veins, some of which stand out boldly on the hillside, were observed as early as 1853, when Lieut. R. S. Williamson, engaged in surveying a prospective route for the proposed transcontinental railroad, saw veins in Tulare County and considered the supply of magnesite "almost unlimited". "The mineral," he wrote, "is snowy white, and being on the side of a high ridge, the outcrops are visible from the plain for a distance of several miles." The Merryman and Mitchell magnesite mines were located in this area. Neither is operating. *Photo by Mary Hill.*

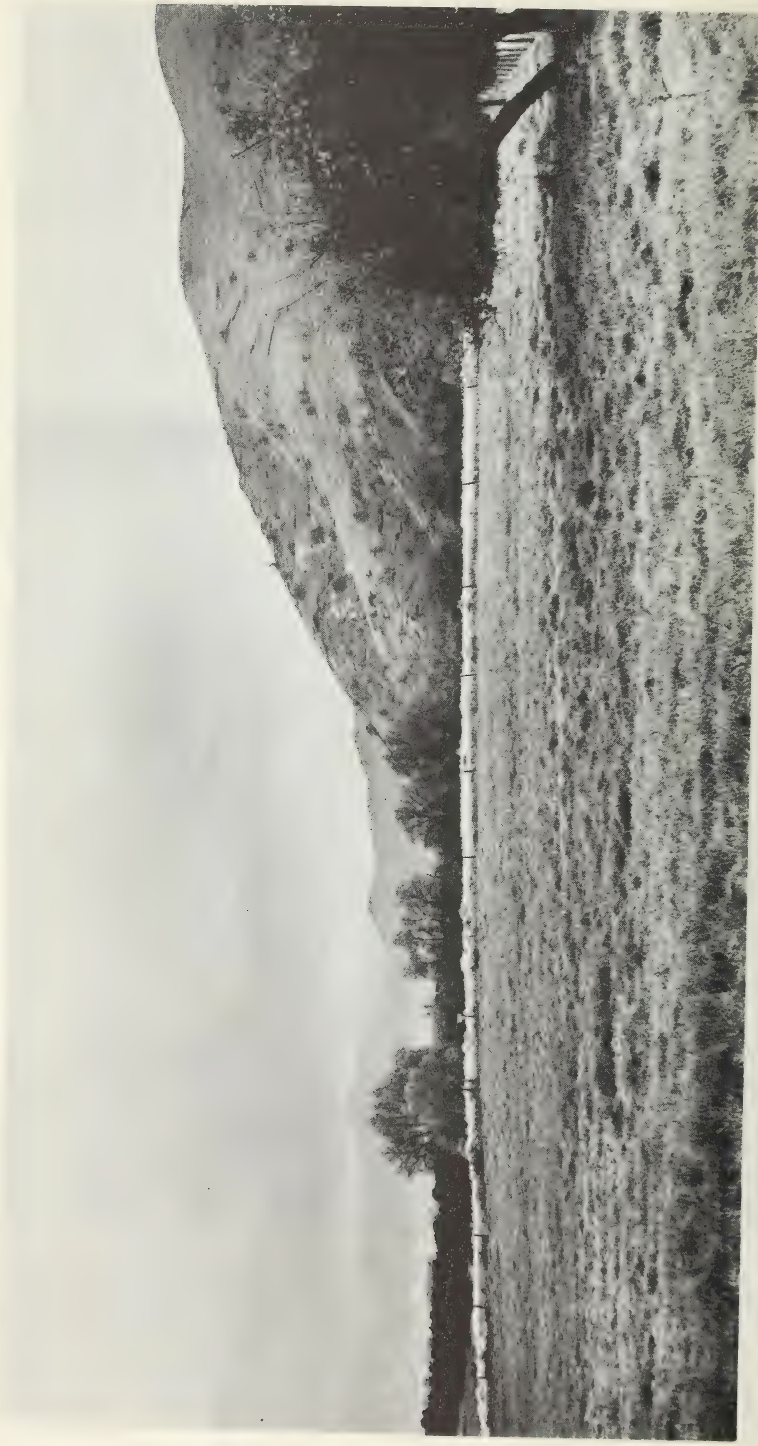

PHOTO 25. Magnesite mines of the Lindsay Mining Company near Success, showing site of tramways and ore chutes. The tramways transported ore around the northeast slope of the hill to chutes (the site of one is marked by a vertical line on the hill slope in the left of the photograph), which dropped it from one elevation to another until it reached the loading bins on the railroad. The outcrops of the magnesite veins here were as much as 4 feet wide. *Photo by Mary Hill.*

PHOTO 26. Tulare Mining Company magnesite mines near Success. The Tulare and Lindsay mines were on the same hill, the Tulare group being north of the Lindsay holdings. In the Tulare group, some magnesite veins thickened from 10 feet at the outcrop to 20 feet at depth, and contained about 40 percent magnesite. From 1915 to 1917 the entire United States production of magnesite came from California, Tulare County being the chief producer. *Photo by Mary Hill.*

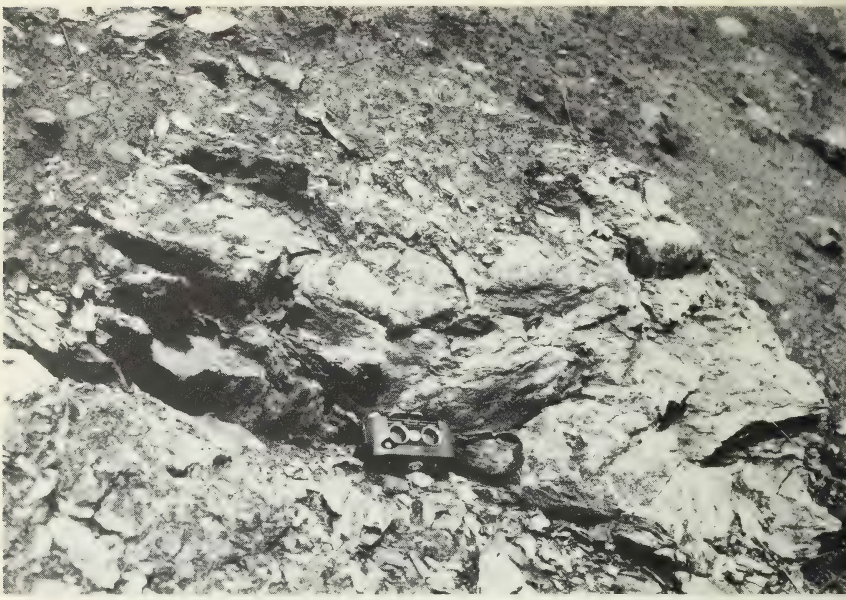

PHOTO 27. Serpentine outcrop near Success. Magnesite in Tulare County is in serpentine; the mines of the former Tulare and Lindsay mining companies shown in photos 25 and 26 were in rock much more highly serpentinized than most other magnesite-bearing rocks in the county. ***Photo by Mary Hill.***

PHOTO 28. Jasperoid—silicified serpentine—near Success. ***Photo by Mary Hill.***

calcining. The calcined product, magnesia, was valued at $32.50 per ton in 1917. In the burning of magnesite (magnesium carbonate), by-product carbon dioxide was also produced. Most of the magnesia from California magnesite was used by Oregon paper mills to digest and whiten pulp. Some was used for refractory bricks and in the chemical industry.

After the close of World War I, the competition of imported magnesite from Europe and the development of fresh reserves in Washington caused a rapid decline in California's magnesite industry. In 1920, the Sierra Magnesite Company was formed and, by purchase or lease, assumed control of the most productive properties in the Porterville district. By 1927, this was the only company mining magnesite in Tulare County. Through organizational changes, these properties came under successive control of the California Chemical Company and the Westvaco Chlorine Products Company. Mineral rights to those properties owned in fee still are retained by the Westvaco Chemical Division, Food Machinery and Chemical Corporation; surface rights were sold for other uses. By 1931, the economic reserves were depleted and magnesite mining ceased in the county. The total production exceeded 500,000 tons valued at about 5 million dollars.

Much of the surface of these lands is used for agriculture and other purposes, and the significance of the mineral deposits is greatly diminished. Current ownership was not determined for most of the deposits (see tabulated list of mines and mineral deposits).

The magnesite in Tulare County lies along a belt that trends north-northwestward from the Porterville deposit, 8 miles east of Porterville, to an area 3 to 6 miles east of Exeter; a few deposits are southeast of Porterville. Magnesite has formed as supergene fracture fillings in weathered serpentine below a lateritized surface. Magnesite veins in most deposits form a stockwork in reddish-brown jasperoidal serpentine, although in some deposits the veins range from a fraction of an inch to 10 feet in width. Selective mining and hand-sorting were required at nearly all deposits, and most of these were mined by relatively shallow workings. Some workings did extend as deep as 500 feet below the outcrop (Bradley 1925, p. 116). One of the most persistent veins was 362 feet long (Bradley 1925, p. 115), but most were considerably shorter. At the Tulare deposit, in addition to individual veins, an entire stockwork was mined, ". . . a face 30′ high by 40′ wide was worked carrying a stockwork of veinlets varying from 6 inches to 2 feet; and of the total material quarried 30% was ore and 70% waste." (Bradley 1925, pp. 126-127.) This was not a common mining practice.

Sand and Gravel

The major sand and gravel operations in Tulare County are located on the Kaweah River near Lemon Cove and on the Tule River near Porterville. In 1956, five sand and gravel producers were operating. These sources yielded 525,147 short tons of sand and gravel valued at $686,419. This was surpassed only by the value of natural gas. The total sand and gravel produced in the county has an estimated value of $6,000,000. Approximately half of this total has been produced since 1947.

Petrographic analyses of gravels from Tule and Kaweah Rivers and Lewis Creek. Based on observations of 200 to 400 pebbles in the ¾-1½" size.

1. Kaweah River—pit run sample near Lemon Cove. 2. Lewis Creek —pit run sample near Lindsay. 3. Tule River —pit run sample near Porterville. 4. Tule River —river bed grab sample at Success Valley.	1 Kaweah	2 Lewis	3 Tule	4 Tule
LITHOLOGIC CLASSIFICATION (¾"-1½" size)	(Percentage of sample)			
PLUTONIC IGNEOUS				
GRANITIC. Chiefly typical Sierran granodiorite with lesser amounts of quartzose porphyritic and gneissic types, and minor aplite and pegmatite. Generally very sound and well shaped. The few deeply weathered pebbles are unsound constituents.	13	--	30	30
GABBROIC. Medium-fine grained iron-rich igneous rocks. Includes some diorite and diabase, mildly metamorphosed (uralitized) rocks and rare serpentine. Sound and well-shaped.	6	--	8	12
METAMORPHIC				
AMPHIBOLITE. Metabasic igneous fine-medium grained, dark greenish-black, sub-schistose to gneissoid, rarely fissile. Heavy, tough, mostly very sound.	43	32	21	13
QUARTZITIC METASEDIMENTARY ROCKS. Some typical quartzite but mostly gneissic and sub-schistose, derived from quartzose sandy sediments, sound and well-shaped.	23	35	37	43
MICACEOUS SCHISTS AND GNEISSES. Many fissile, and weakened by weathering. Distinctly an inferior constituent.	8	20	3	2
LIGHT-COLORED METAVOLCANIC ROCKS AND HORNFELS. Light-colored, massive, relict flow and porphyritic textures, moderately metamorphosed, very hard. May include some metasedimentary hornfelses.	7	7	<1	--
SLATES AND PHYLLITES. Low grade meta-argillites.	--	6	1	<1
PHYSICAL QUALITY CLASSIFICATION				
Percentage of individual pebbles: good and satisfactory	70	26	63	80
Percentage of individual pebbles: fair	24	55	25	17
Percentage of individual pebbles: poor	6	19	12	3
DEGREE OF ROUNDNESS CLASSIFICATION				
Percentage of individual pebbles: Well-rounded	1	0	3	3
Percentage of individual pebbles: Sub-rounded and sub-angular	91	71	87	93
Percentage of individual pebbles: Angular	8	29	10	4
SHAPE CLASSIFICATION				
Percentage of very flat particles	18	28	13	14

Most of the county's output of sand and gravel is used as bituminous aggregate in road-building, and as concrete aggregate for highways and general construction. At least 40,000 tons of sand and gravel are used each month within the county in the manufacture of concrete irrigation pipe, concrete blocks, and septic tanks and burial vaults. In 1956, eleven such producers of concrete products, located in Porterville, Visalia, Dinuba, Woodlake, Tulare, and Exeter, were active. Aggregate from Tulare County has been used by the U. S. Bureau of Reclamation in the construction of portions of the Friant-Kern canal.

The bulk of Tulare County's sand and gravel production has been obtained from natural sand and gravel in stream deposits. The west side of the Sierra Nevada is drained by streams with steep gradients. Huge volumes of sand and gravel are transported in flood stage, and are deposited along the present stream courses and adjacent flood plains. As these streams are dry a large part of the year, the deposits constitute readily accessible and easily mineable sources of aggregate materials. The natural abrasive action of the stream grinds up and removes most of the soft, weak rocks and concentrates the harder and firmer particles. In addition, excessive amounts of silt and clay are washed out. However, some deposits are undesirable as they contain harmful ingredients such as physically or chemically unsound rocks. As sand and gravel are derived from the various rock types representing the various rocks within the drainage area of the stream, they show a wide range in chemical composition and degree of weathering.

Three streams have been major sources of sand and gravel in Tulare County—the Kaweah River, Lewis Creek, and the Tule River. The quality of material in these streams differs markedly. Deposits on the Kaweah River are of highest quality, those on Lewis Creek of inferior quality. Comparison of the lithologic characteristics and physical properties of gravel samples from deposits on the Kaweah River near Lemon Cove, Lewis Creek near Lindsay, and the Tule River near Porterville and in Success Valley is presented in the accompanying table. Data for the table were prepared by Mr. Ira E. Klein, geologist with the U. S. Bureau of Reclamation, Sacramento. Based on petrographic observations, the three deposits are characterized as follows:

PHOTO 29. Quaternary terrace gravel of the Tule River in roadcut, Highway 190 near Success. *Photo by Mary Hill.*

Physical property tests conducted on sand and gravel samples from Lewis Creek and the Kaweah River, by the U. S. Bureau of Reclamation Laboratory, Denver.

	KAWEAH RIVER AT TERMINOUS BEACH		LEWIS CREEK, SAMPLE NO. 1		LEWIS CREEK, SAMPLE NO. 2	
GRAVEL GRADING						
Cumulative percent retained 1½″	0		Data lacking		33	
¾″	52				61	
⅜″	80				84	
No. 4	100				100	
Percent sand	59.1				37.8	
SAND GRADING	Pit run	Washed	Pit run	Washed	Pit run	Washed
Cumulative percent No. 4	--	--	3	2	--	--
8	13	12	22	20	15	18
16	35	37	45	45	39	41
30	56	59	68	69	63	66
50	77	81	88	89	84	87
100	91	95	97	97	94	97
Pan	100	100	100	100	100	100
Percent silt in sand	4.3		3.8		4.3	
Organic content	No. 3		No. 2		No. 2	
SPECIFIC GRAVITY						
Sand	2.70	2.70	2.74	2.71	2.68	2.72
Gravel	2.87		2.68		2.68	
ABSORPTION (percent)						
Sand	--	--	0.9	0.8	0.9	0.5
Gravel	0.6		0.8		0.9	
SODIUM SULFATE SOUNDNESS						
Percent loss (5 cycles)						
Sand	4.1		8.2		9.8	
Gravel	2.4		9.2		18.7	
LOS ANGELES ABRASION						
Percent loss						
Gravel, 100 rev.	4.8		5.0		7.8	
500 rev.	19.0		27.0		32.2	

(1) The gravel from Lewis Creek is definitely inferior to that of the Tule and Kaweah Rivers. Lewis Creek contains more very flat particles than any other commercially developed gravel in that portion of the San Joaquin Valley. The samples from the Kaweah and the Tule in Success Valley are of very high quality for use as concrete aggregate.

(2) Lewis Creek deposits are characterized by gravel containing metamorphic rock types exclusively; granite and other plutonic igneous rock types are conspicuously absent.

(3) The abundance of amphibolite in the gravel of Kaweah River (43 percent) distinguishes that gravel from Tule River gravel, which contains from 13 to 21 percent amphibolite. The Kaweah gravel contains only 19 percent plutonic igneous rock types as opposed to more than 38 percent in the Tule River gravels.

(4) The deposits are not chemically reactive. No Tertiary or Quaternary volcanic rocks or other reactive types are present.

In 1948 the U. S. Bureau of Reclamation conducted routine standard acceptance tests on sources of material for use in the construction of the Friant-Kern Canal. Test data from the Bureau of Reclamation Denver Laboratory on two samples from Lewis Creek and one sample from the Kaweah River are presented in the accompanying table.

According to the Bureau concrete technicians, the sample from Kaweah River and sample No. 1 from Lewis Creek were considered suitable for use as concrete aggregate, provided proper gradings could be obtained, and the sand washed to remove excess silt. However, sample No. 2 from Lewis Creek was found to be of inferior quality, and was considered unsuitable for use in concrete.

The stream deposits of sand and gravel along the Kaweah River near Lemon Cove and especially those along the Tule River, between Porterville and Success, constitute important reserves of construction materials, particularly for use on the west side of the San Joaquin Valley where suitable materials are lacking. The proposed new state highway and federal or state canal system on the west side of the valley will require large volumes of concrete aggregate which may have to be hauled from deposits on the east side.

Prior to World War II the majority of the commercial sand and gravel operations in Tulare County consisted of sand pits operated by manufacturers of concrete products, such as concrete pipe (Franke 1930, pp. 462-464). These concerns used local sand and purchased gravel from established plants in Fresno County. Now, concrete products manufacturers purchase their materials from one commercial sand plant and three sand and gravel operations within the county, although a certain amount of sand and gravel is still purchased from plants at Sanger in Fresno County. Following are descriptions of the plants operating in Tulare County in 1954.

Charter Oaks Sand. Location: S½SE¼ section 17, T. 18 S., R. 26 E., M.D., on the flood plain of the St. Johns River (a branch of the Kaweah River) at the south end of Venice Hills in the Exeter quadrangle. Ownership: Mr. Bud Minecke, Visalia; operator is Mr. W. W. Williams.

Charter Oaks is a sand-producing operation. A drag line is hired periodically to dredge and pile sand along the river bank. The sand is then trucked about 300 yards to a washing plant where it is dumped from a ramp, over a grizzly. A belt conveyor delivers the sand to a wet screen above the storage bins where the silt is removed. Only one man is hired full time. Most of the concrete pipe manufacturers in the Woodlake-Visalia-Exeter area buy their sand from Charter Oaks.

Middletons Sequoia Rock Company. Location: NE¼ section 3, T. 22 S., R. 28 E., M.D., in the Kaweah quadrangle, 3½ miles east of Porterville, on the bank of the Tule River. Ownership: Middletons Sequoia Rock Company, Porterville.

Sand and gravel are excavated from the flood plain and stream bed of the Tule River and loaded into dump trucks which haul a distance of several thousand feet to the crushing and washing plant. The plant was built in 1953. Cobbles, gravel, and sand are dumped over a 14-inch grizzly at the head of an inclined truck-ramp. The material falls into

PHOTO 30. Middletons Sequoia Rock Company plant. Cobbles, gravel, and sand taken from the flood plain and stream bed of the Tule River are dumped onto a grizzly at the inclined ramp. The material is crushed and lifted by the conveyor belt to the top of the washing plant, where it is separated into clean products of 1-inch, $\frac{3}{8}$-inch, and $\frac{1}{4}$-inch rock. *Photo by Mary Hill.*

a temporary storage bin from which a constant discharge feeds an 18 x 35 jaw-crusher which reduces the coarse gravel to about minus 2-inch. A conveyor belt elevates the crushed material to the top of the washing plant where it is wet-screened on a three-deck vibrating screen. Three products are discharged by separate conveyor belts to the top of the stockpiles. These products are 1-inch, $\frac{3}{8}$-inch, and $\frac{1}{4}$-inch rock. The plus 1-inch material discharges by gravity to a Symons 3-foot cone crusher for further size reduction. The recrushed material returns to the three-deck screen for classification. The sand and slime flows by gravity to a classifier. The sand is discharged onto a belt conveyor and stockpiled; the slime and wash water are piped to waste.

Standard products which are marketed are $1\frac{1}{2}$-inch to 1-inch rock, 1-inch to $\frac{3}{8}$-inch rock, $\frac{3}{8}$- to $\frac{1}{4}$-inch pea gravel, plaster sand, and concrete sand. A total of 19 men are employed and plant capacity is stated to be 150 tons per hour. The company also operates a ready-mix service.

Pacific Cement and Aggregates Plant No. 133. Location: W$\frac{1}{2}$SW$\frac{1}{4}$ section 35 and E$\frac{1}{2}$SE$\frac{1}{4}$ section 34, T. 17 S., R. 27 E., M.D., in the Woodlake quadrangle 1 mile north of Lemon Cove. Ownership: Pacific Cement and Aggregates, Inc.

This sand and gravel pit was operated by Sequoia Rock Company 1946-49. In 1949 they merged with Middletons Sequoia Rock Company of Porterville and operated as Middletons Sequoia Rock Company until 1951. In November of that year the pit was acquired by Pacific Coast Aggregate Co. (now Pacific Cement and Aggregate, Inc.).

Sand and gravel excavated from the stream bed and flood plain of the Kaweah River is hauled about 2,000 feet to the crushing and screen-

ing plant. The capacity of the loading and hauling equipment is more than 225 tons per hour. In the event of a breakdown at the crusher, the carriers dump on a stockpile near the crusher ramp. In the event of a breakdown at the pit, the crusher and washing plant may be fed from the ready-stockpile by a standby 1¼-yard shovel.

In the plant, oversize gravel is crushed by two jaw-crushers and one cone crusher. The sand is washed and classified by a 24-inch screw classifier. The capacity of the plant ranges from 120 tons per hour of crushed rock to more than 250 tons per hour for stream run material that requires little crushing.

Standard products produced are 6-mesh to ⅜-inch, ⅜-inch to ½-inch, ½-inch to ¾-inch, ⅜-inch to ¾-inch, ⅜-inch to 1-inch, ½-inch to 1-inch, 1-inch to 1½-inch, 1½-inch to 2½-inch (not standard), 1-inch maximum crusher-run surfacing, 1½-inch maximum crusher-run, special grade concrete sand, and flume sand (silt). During 1955 equipment was installed to produce black-top road surfacing material from the surplus sand in stock.

Quiram & Sons. Location: Section 31, T. 21 S., R. 28 E., M.D., on the Tule River ½-mile east of Porterville in the Kaweah quadrangle. Ownership: E. F. Quiram & Sons, 406 Garden Street, Porterville.

Quiram & Sons' operation is located along a portion of the flood plain of the Tule River just west of the foothills. Sand and gravel is excavated by a ½-yard dragline and hauled 300 feet by dump trucks to a grizzly ramp. Plus 8-inch rock is rejected. A jaw-crusher stationed below the grizzly reduces the material to about 2½-inch size. The sized material is lifted by a conveyor belt to a portable crushing plant which further reduces the rock in a jaw-crusher and roll-crusher. The capacity of the plant is 300 tons per day. Three products are made—sand, pea gravel, and 1-inch to 1½-inch rock. Some of these products are used in the operator's ready-mix plant, a concrete-pipe machine, and equipment for making septic tanks. Sand and pea gravel also are sold locally to manufacturers of drain tile, irrigation and culvert tile, and septic tanks.

Crushed and Broken Stone

The amount of crushed and broken stone produced in Tulare County prior to 1913 is not shown. Between the years 1913 and 1931 stone production statistics included sand and gravel, crushed stone, rubble, decomposed granite, and minor commodities such as soapstone and silica. Since 1947, the production of sand and gravel has been tabulated separately; however, crushed stone has been combined with sand and gravel to conceal confidential statistics.

In the 1920s and 1930s, crushed stone was produced at granite dimension stone quarries where waste fragments of granite were utilized. About 34,000 cubic yards of crushed granite valued at about $20,000 were produced during this period.

Since 1947, the production of crushed and broken stone has consisted principally of broken stone used as rip rap and decomposed granite used in macadam on county roads. A small quantity of soapstone, talc, marble, and silica rock also have been produced. The total value of crushed stone (exclusive of sand and gravel and crushed stream-run

gravel, limestone, and granite dimension stone) is estimated to be $2,000,000.

Dimension Stone—Granite

Between 1889 and 1933, the production of dimension stone was an important industry in Tulare County. Granite valued at about $700,000 was produced from quarries in the foothills east of Porterville and Exeter for use as monumental stone, building stone, and curbing.

In the stone industry, the term ''granite'' is used to refer to various igneous rocks with granitic textures. Such closely related rocks as syenite, granite, diorite, and gabbro, which range in color from light to dark and in composition from acidic to basic, commonly are referred to commercially as granites.

A dark-gray gabbro-diorite (Porterville black granite) and a pale gray biotite granite (Porterville white granite) are found as residual boulders and in massive exposures that comprise low hills near the base of the Sierra Nevada on the east side of the San Joaquin Valley. These two rock types have been the principal sources of dimension stone in the county. Commercial production began in 1889 at the Rocky Point quarry east of Exeter and ended in 1953 when the Oakland Granite and Marble Company shut down its quarry near Success. From 1933-53, production was restricted to small amounts of black granite, quarried intermittently for use as monumental stone. Since 1953, there has been no recorded production of dimension stone in the county.

Porterville Black Granite Quarry. Location: NW¼ section 29, T. 21 S., R. 29 E., M.D., in the Kaweah quadrangle. Owner: W. W. Gainey, 130 Lunado Way, San Francisco.

PHOTO 31. Boulders of granitic rock covered by moss and lichen, Yokohl Valley. A large sheet exfoliating from the main mass is clearly visible in the center of the picture. *Photo by Mary Hill.*

PHOTO 32. A natural sheeting surface of granitic rock on the bank of the Kaweah River 5 miles northeast of Lemon Cove. *Photo by Mary Hill*

PHOTO 33. Residual boulders of gabbro-diorite and gin pole at the Porterville Black Granite quarry near Success. The quarry supplied dimension and monumental stone from 1889 to 1953. *Photo by Mary Hill.*

PHOTO 34. View into the pit of the Porterville Black Granite quarry. The pit is now about 100 feet deep. *Photo by Mary Hill.*

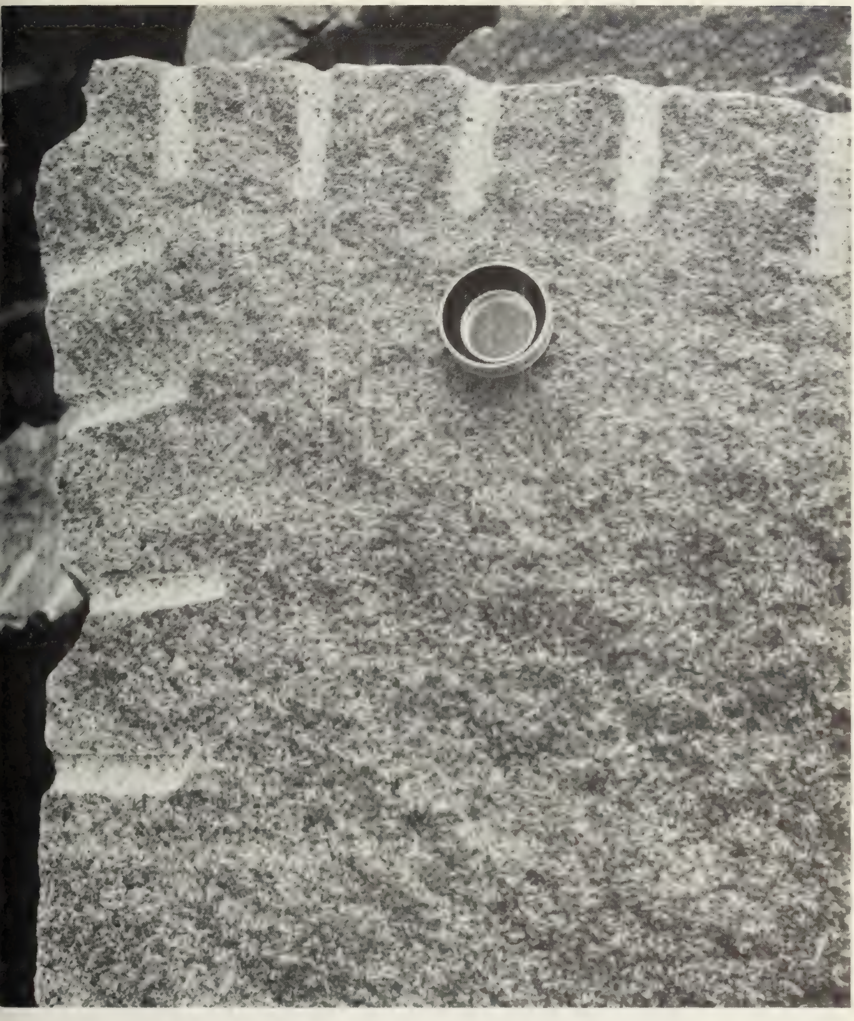

PHOTO 35. Quarried stone at the Porterville Black Granite quarry showing typical granitic texture and dark color of gabbroic rock. Sunshade is approximately 2 inches in diameter. *Photo by Mary Hill.*

This quarry was first operated by the California Granite Company from 1915-28, and subsequently by the McGilvray Raymond Corporation from 1928-33, in conjunction with the Porterville White Granite quarries. More recently the quarry was under lease to the Oakland Granite and Marble Company, 6630 Foothill Blvd., Oakland, who operated until 1953.

The Porterville black granite is a dark-gray gabbro-diorite composed of andesine feldspar, augite, and biotite that takes a good polish. The quarry was opened on the west side of a low hill in a small granite outcrop. The pit is now approximately 150 feet long, 75 feet wide, and 100 feet deep. Rough blocks were removed using channeling methods

of drilling and were shipped to a company-owned finishing plant at Raymond. The stone was used as facing on buildings such as the Chapman-DeWolfe building at 341 Montgomery Street, San Francisco, but its most recent popularity was as a monumental stone sold under the trade name "Porterville Black."

PHOTO 36. Porterville White Granite quarry, near Porterville. The hillside is granite; quarry site is marked by vertical cliffs and piles of quarried stone. *Photo by Mary Hill.*

Porterville White Granite Quarry. Location: section 27, T. 21 S., R. 28 E., M.D., 4 miles east of Porterville, in the Kaweah quadrangle. Ownership: not determined.

The Porterville White Granite quarry was owned and operated by the California Granite Company from 1915-28. The McGilvray Raymond Corporation assumed operations in 1928 and worked the quarry until 1929.

Two quarries were opened on the southwest slope of a low hill on a granite outcrop approximately a mile wide that extends for several miles in a northeasterly direction. The granite is in contact with serpentine on both sides. The Porterville white granite is a light-gray, medium- to coarse-grained biotite granite that weighs about 180 pounds per cubic foot. The stone cleaves fairly straight, and takes a good polish; these qualities made it desirable as a dimension stone. A close joint pattern limited the size of blocks that could be quarried, but blocks large enough for building stone were obtained.

From 1915-18, 178,435 cubic feet valued at $541,293 was marketed for monumental stone. During the same interval 28,482 cubic feet valued at $84,866 was produced for use as building stone. A total of 37,922 linear feet of granite curbing valued at $50,597 was produced in 1915-17 and in 1925. Rough blocks of granite were removed by drilling and wedging and shipped by rail to a finishing plant at Raymond.

PHOTO 37. Porterville White Granite quarry, near Porterville. The rock is a light-gray biotite granite that cleaves readily along a straight course and takes a high polish. The quarry has not been worked in recent years. *Photo by Mary Hill.*

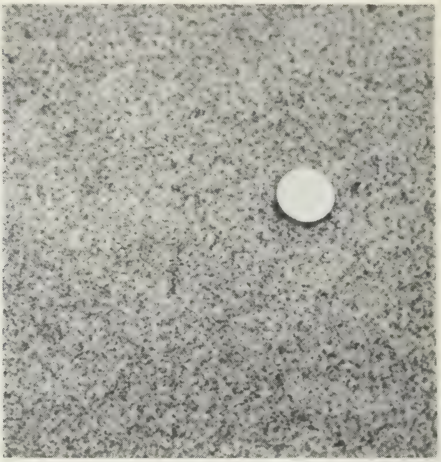

PHOTO 38. Detail of quarried slab of Porterville white granite showing medium texture and pepper-and-salt appearance. Lens cap is approximately the size of a silver dollar. *Photo by Mary Hill.*

An average of 20 men was employed during periods of greatest activity. The last recorded production of Porterville white granite was in 1929.

Rocky Point Quarry. Location: section 8, T. 19 S., R. 27 E., M.D., about 4 miles east of Exeter at the eastern base of Rocky Hill in the Rocky Hill quadrangle. Ownership: not determined.

The Rocky Point quarry was owned and operated by the Rocky Point Granite Works (D. R. Griffith and R. H. Owens, Exeter) from 1889 to 1914.

The Rocky Point granite is a gray, fine-grained rock of uniform texture and color that splits readily in any direction and takes a fine polish. The granite is divided by prominent joints, which dip north about 30 degrees, into sheets 2 to 25 feet thick, thus permitting all sizes of stone to be obtained. The blocks, removed by drilling and wedging, were shipped to Exeter for finishing. The amount of rock produced prior to 1894 is not recorded; however, between 1894 and 1910 a total of 51,958 cubic feet of monumental stone valued at $92,460 was quarried. The last year for which production from this quarry is recorded is 1910.

Sulfur

Native sulfur has not been found in Tulare County; however, sulfur in the form of sulfides and sulfates is available. The principal potential source of sulfur is the pyrrhotite-pyrite masses known to be in the Mineral King district. These deposits are not of present commercial interest, owing mainly to the inaccessibility of the area. Gypsum (calcium sulfate) is found sparingly in some of the sedimentary rocks exposed in the valley regions. Small amounts of gypsite (impure gypsum) have been used locally as an agricultural mineral.

PHOTO 39. View of Rocky Point quarry on Rocky Hill near Exeter. The pronounced joint pattern in the granite on Rocky Hill allowed the Rocky Point Granite Works to produce many sizes of granite blocks. The quarry has not been worked since 1910. *Photo by Mary Hill.*

PHOTO 40. Monument of rough "black granite" on base of "white granite." The black granite was particularly popular for monumental stone. *Photo by Mary Hill.*

PHOTO 41. Monument of polished gabbro (black granite)) on base of polished granite. *Photo by Mary Hill.*

Mineral Fuels

Oil and Gas

Exploration for oil and gas in Tulare County began at least as early as 1911, and since that time about 300 wildcat wells have been drilled. Although only modest success has been realized in the discovery of gas in the Trico field and oil in the Deer Creek-Terra Bella area, additional accumulations may yet be discovered. The known potential accumulations of oil and gas are restricted entirely to the San Joaquin Valley portion of the county which is underlain by a sequence of clastic sedimentary strata of Eocene to Quaternary age. These marine and continental sediments, which overlie granitic and metamorphic basement rocks of the Sierra Nevada complex, are veneer thin to the east but 12,000 feet or more thick near the Trico gas field. It is probable that untested structural or stratigraphic traps exist within the sedimentary rocks, and these traps may confine additional accumulations of oil or gas.

Total production of oil and gas through 1956 in Tulare County is valued at $11,626,101, most of which is from gas produced from the Trico field. Practically all of the oil, valued at about $350,000, has been obtained from the Deer Creek field.

Trico Gas Field. The Trico gas field is located mostly in the southwestern corner of Tulare County, but extends into Kings and Kern Counties on the southeast and northwest, respectively. It is the largest dry-gas field in the San Joaquin Valley with reference to its extent, current production, and reserves. However, according to oil and gas terminology, it is not considered to be a major gas field.

The Trico area was first prospected for gas in 1932 on the basis of abundant gas shows in water wells of the Tulare Basin and a very

PHOTO 42. Gas-scrubbing plant of the Southern California Gas Company, Trico gas field. *Photo by Mary Hill.*

PHOTO 43. Seymour Boltz No. 2 well, Standard of California, Trico gas field. *Photo by Mary Hill.*

slight topographic high. Three wells were drilled on this high, located in Kings County about 4 miles southwest of the present field, but none encountered commercial showings of gas. In 1934, Trico Oil and Gas Company located its well No. 2 in section 3, T. 25 S., R. 23 E., M.D., 6 miles farther east in Kern County, on the basis of reflection seismograph data, and the completion of this well in November of that year resulted in the discovery of the Trico gas field (Doell 1943, p. 551). The well was completed at a depth of 2476 feet in sands of the First Mya fossil zone of the San Joaquin clay of upper Pliocene age. Standard Oil Company of California joined in the development of the field, and during the next 4 years 10 wells were drilled, all in the southern part of the field. Non-commercial showings also were discovered during this same period in sands in the southern portion of the field about 800 feet below the First Mya sand. This was known as the Widgeon zone, which is considered to be the equivalent of the Atwell Island zone discovered in 1945 at the north end of the field. In 1939 a gas pipeline was completed, and delivery of gas to the Pacific Gas & Electric Company began. During the next 2 years 17 wells were completed, all in the First Mya zone. By the end of this period, only the southern limits of the field had been determined (Bailey and Burger 1946, p. 4).

In 1945 Trico Oil and Gas Company extended the field 2 miles to the northwest by completing its Atwell Island Community No. 1 in section 7, T. 24 S., R. 23 E., M.D., Tulare County. This well not only greatly extended the producing area of the First Mya zone, but also discovered a commercial gas pool about 800 feet lower in the Second

Mya zone which was designated the Atwell Island zone. The structure of the field had been established by 1947 as a closed anticline which confines the gas field to a length of about 9½ miles and a width of just over 2 miles. Maximum closure is about 100 feet for the First Mya gas sand, but somewhat less for the lower producing sands. As of December 31, 1955, the productive acreage of the field was 10,408.

Although the San Joaquin clay overlies about 8,000 feet of sedimentary rocks, Eocene to lower Pliocene in age, only four deep test wells have been drilled, and all of these are located along the northeast margin of the field. All were drilled to depths greater than 11,000 feet, and none met with significant success. However, one well, the Associated Oil Company's ''Daniel'' 35, encountered light oil in the 10,760-10,900 foot interval; but it was eventually completed as a gas producer in the First Mya zone. Two of the other wells, both drilled and abandoned in 1954, were restricted to testing only those formations below 6000 feet, but according to Pierce (1954, p. 101), ''Etchegoin (Pliocene) sand stringers encountered in these wells between 5,000 feet and 6,000 feet are believed to warrant future testing for gas production.''

Gas production in 1956 from that portion of the field lying in Tulare County was estimated to be 6,449,000 Mcf (thousand cubic feet), valued at $1,612,000, and the cumulative total is 69,334,611 Mcf valued at $11,276,101. This represents a large proportion of the 1956 and cumulative production for the entire field of 9,434,122 Mcf and 107,779,600 Mcf, respectively. As of December 1956, there were 65 wells producing and 21 shut in (Conservation Committee of California Oil Producers, 1956, table 29). Proved recoverable reserves for the entire field are estimated to be 147,407,532 Mcf, as of January 1, 1957.

Terra Bella Area. The first oil to be produced in Tulare County was discovered in the Terra Bella area in June 1930, when Terra Bella Oil Company successfully completed its ''Gardner'' 1 in section 35, T. 22 S., R. 27 E., M.D. The nonmarine Walker formation (lower Miocene to Eocene?) produced 17° gravity oil from the interval 890-916 feet. Initial production was 68 barrels of oil and 100 barrels of water per day, but the yield of oil decreased and the water increased rapidly, causing the operator to recomplete the well in August. However, oil production continued to drop and water increased (Musser 1930, p. 57).

The initial discovery was all the stimulus needed to attract attention, and by the end of 1931 more than 20 operators had drilled approximately 27 more wells within a radius of several miles. Many of these wells penetrated thin streaks of oil sand, but only three were completed as producers (Musser 1930, pp. 57-60; 1931, pp. 45-47). Since that time only one or two additional wells have been brought in, and they were small producers. After the initial development, oil was produced only intermittently, and in 1955 the area was finally abandoned. Cumulative production for the Terra Bella area is about 17,651 barrels of oil, most of which came from wells located within a few hundred yards of the discovery well. This figure does not include 7,348 barrels of oil previously listed for the Terra Bella area, but which is credited to the Deer Creek field.

*Exploratory wells drilled for oil and gas in Tulare County through 1955.**

T.	R.	Sec.	B&M	Name of company and well	Date started	Date abandoned	Total depth (feet)	Geology (at bottom, unless otherwise indicated)
16S	23E	12	MD	Martin Pet. Co. (Dinuba Oil & Pet. Co.); No. 1 (Brians 1)	6–25	1927	1,670	Etchegoin
16S	23E	17	MD	Reid, Gene, Drlg., Inc.; Giannini 1	2–53	1953	2,447	Weathered basement (slate) 2,357, hard basement (igneous rock) 2,411
16S	23E	28	MD	Agoil Co.; Agoil 1	8–54	1955	3,333	Top M. Miocene (?) 2,500
16S	23E	28	MD	Agoil Co.; Agoil 2	9–54	1955	2,500	
16S	23E	28	MD	Alford, John W.; Williams 1	10–36	1937	1,023	Etchegoin
16S	23E	28	MD	Frakes Oil Co.; Toscon 1	12–46	1947	2,930	Basement
16S	23E	28	MD	Goble, W. E.; No. 1	10–41	1941	1,870	Miocene ?
16S	23E	29	MD	Kingsburg Explor. Co.; No. 1	11–31	1934	2,897	Kern River ?
16S	23E	29	MD	Kings River Oil Pool; No. 1	4–35	1936	3,157	Cretaceous
16S	23E	34	MD	Transcal Drilling Co.; Harris 1	2–46	1946	2,603	Basement
16S	24E	20	MD	Amerada Petrol. Corp.; Comm. 20–1	3–44	1944	1,231	Basement
16S	24E	21	MD	Amerada Petrol. Corp.; Comm. 21–1	2–44	1944	518	Basement
16S	24E	26	MD	Amerada Petrol. Corp.; Comm. 26–2	3–44	1944	1,078	Basement
16S	24E	28	MD	Amerada Petrol. Corp.; Comm. 28–1	3–44	1944	907	Basement
16S	24E	29	MD	Amerada Petrol. Corp.; Comm. 29–2	3–44	1944	1,391	Basement
16S	24E	33	MD	A. O. Margoles, Hovsepian 1	9–54	1954	1,016	
17S	23E	15	MD	Superior Oil Co.; Pratt 1	1–47	1947	3,887	Basement
17S	23E	32	MD	Wilson, Daisy; No. 1	1–23	pre-1925	500	Tulare
17S	24E	1	MD	Schneider, Winifred; Pritchett 1	9–45	1945	1,334	Basement
17S	24E	15	MD	Langstaff, D. R.; Bennett 1	9–38	1938	1,210	
17S	24E	24	MD	Inland Valley Oil Co.; No. 1	10–22	1936	2,090	Pliocene ?
17S	25E	3	MD	Ebonoro Oil Co.; McCarrell 1	3–51	1951	492	Top granite 487
17S	25E	15	MD	Ebonoro Oil Co.; Alves 1	3–51	1951	473	Top weathered granite 425, top hard granite 440
17S	25E	18	MD	Steele Pet. Co.; Steele Pet.-Visalia No.1	5–50	1950	1,033	Granite 1,000
18S	23E	11	MD	Ulrich-Lowell Oil Co.; Logsdon 1	2–54	1954	4,083	
18S	23E	12	MD	United Exploration Co.; United 1	11–46	1946	3,836	Basement
18S	23E	15	MD	McDuffie, Wm. C.; Bennett 1	1–46	1946	5,370	Miocene ?
18S	24E	7	MD	Superior Oil Co.; Huntley 1	12–46	1947	3,811	Basement
18S	24E	8	MD	Superior Oil Co.; McGee 18–8	4–47	1947	3,650	Basement ?
18S	25E	16	MD	Andrews, Miles; Carter-McAllister 1	10–48	1948	1,765	Basement
18S	25E	16	MD	King Development Co.; A. K. 2	9–52	1952	1,757	Granite (?)
18S	25E	21	MD	Carter, W. J.; Carter-Chedester 1	5–48	1948	1,677	Basement
19S	23E	10	MD	Stone, M. H.; Overland-Stone 1	11–53	1953	1,125	
19S	24E	33	MD	Richfield Oil Corp.; No. Tulare Comm. 1-1	4–42	1942	5,356	Basement
19S	25E	14	MD	Eureka Ref. Corp.; Eureka-Wright-Hart 1	3–52	1952	1,953	Basement
19S	26E	33	MD	J. F. Wilcox; Wilcox-Hinkel 1	10–54	1954	1,297	Top basement 1,276

19S	26E	34	MD	John F. Wilcox; Orton 1	8–55	1955	1,040	Top granite 1,037
19S	27E	17	MD	Thew, Richard; No. 1	7–24	1924	720	
19S	27E	35	MD	Givan Cons. Oil Corp.; No. 1	----	1921	500	
20S	24E	1	MD	Tulare Oil Co.; No. 1	10–22	----	3,247	Etchegoin
20S	24E	35	MD	Richfield Oil Corp.; Churchill 1	6–42	1942	5,566	Basement
20S	25E	29	MD	Brittain-Terminal Oil Well; Gieck-Stephens 1	10–29	1931	4,160	Basement?
20S	25E	29	MD	Paul E. Olson; Sturdevant 1	8–54	1955	1,028	
20S	25E	33	MD	Paul E. Olson; Presley 1	12–54	1955	2,261	
20S	25E	33	MD	Paul E. Olson; Presley 2	6–55	1955	2,909	
20S	26E	12	MD	King Development Co.; A. K. 1	8–52	1952	1,071	Basement
20S	26E	15	MD	Lindsay Comm. Dev. Assoc.; No. 1	5–51	1951	1,176	
20S	26E	23	MD	Lindsay Comm. Dev. Assoc.; No. 2	6–51	1951	1,341	
20S	26E	24	MD	Beyerbach, Charles; Keeley 1	4–53	1953	1,173	Top weathered granite 1,151, hard granite 1,170
20S	26E	24	MD	Bureau of Reclam.; Ralph Keeley 20-26-24G	1951	----	1,070	Test hole drilled for water observation. Oil shows in altered tuff from interval 1,047′-1,058′
20S	26E	24	MD	Shell Oil Co.; Keeley Comm. 44x-24	5–51	1951	1,187	Basement
20S	26E	24	MD	Navy Oil Co., Inc.; Keeley 1	6–55	1955	1,220	Top basement 1,170′. Bottomed in granite
20S	26E	24	MD	Navy Oil Co., Inc.; Orton 1	11–55	1955	1,184	Top basement 1,171
20S	26E	28	MD	Hitchecock, J. R.; No. 1	1–22	1922	1,330	
20S	26E	32	MD	Ajax Oil & Development Co.; Neal 1	11–54	1954	2,717	Top of granite 2,702′
20S	27E	30	MD	Lindsay Comm. Dev. Assoc.; No. 3	6–51	1951	1,074	
21S	23E	17	MD	Tulare Dome Oil Co.; Tulare Dome 1	7–37	1946	3,125	Pliocene
21S	23E	19	MD	Palmer, Geo. K. (Wm. Gilbert; Kings-Tulare Oil Syn.; M. W. Bartholomew); Palmer 1	6–22	1934	5,643	Etchegoin
21S	23E	26	MD	C. W. Colgrove; Green 48-26	4–54	1954	5,247	Top McLure shale 4,980′ Bottomed in basement (?)
21S	23E	33	MD	Pacific Western Oil Corp. (Elmer C. Von Glahn); Green Cattle 1	11–45	1948	9,050	Eocene
21S	25E	1	MD	Richfield Oil Corp.; Hewitt 1	12–41	1941	3,486	Basement
21S	25E	5	MD	Standard Oil Co.; Kern Cy. 1-2		pre-1925	5,865	Pliocene?
21S	25E	27	MD	Trico Oil & Gas Co.; Callison 1	9–36	1937	4,686	Miocene
21S	25E	33	MD	Tide Water Assoc. Oil Co.; Hoffman 24	6–45	1945	5,148	Basement
21S	25E	35	MD	Trico Oil & Gas Co.; Valley 2	11–37	1937	3,704	Miocene
21S	25E	36	MD	Trico Oil & Gas Co.; Valley 1	5–37	1937	4,337	Miocene
21S	26E	13	MD	Birch, A. Otis (Baker Oil Co.); Baker 1	7–21	1928	3,504	
21S	26E	21	MD	Tide Water Assoc. Oil Co.; Core Hole 76-21	8–43	1943	2,595	Basement?
21S	26E	34	MD	Tide Water Assoc. Oil Co.; Core Hole 54-34	8–43	1943	2,709	Basement?
21S	26E	35	MD	Tide Water Assoc. Oil Co.; Core Hole 84-35	9–43	1943	2,233	Basement?
21S	27E	10	MD	G. E. McKinney and W. H. Myers; Well 1	11–55	1955	606	
21S	27E	17	MD	Pacific Expl. Corp.; Castle 1	7–35	1936	1,700	
21S	27E	27	MD	McGlashan, J. H.; No. 1	12–21	1924	75	
21S	27E	32	MD	Tule River Syndicate; Andrews-Prestage 1	7–54	1954	1,529	Top of Mariposa slate 1,500′
21S	27E	35	MD	McCoy, W. D.; No. 1	12–30	1931	872	Mariposa slate
21S	29E	22	MD	Olsson, C. H.; Moore 1	8–52	1952	90	Top granite at 30

Exploratory wells drilled for oil and gas in Tulare County through 1955.—Continued.*

T.	R.	Sec.	B&M	Name of company and well	Date started	Date abandoned	Total depth (feet)	Geology (at bottom, unless otherwise indicated)
22S	23E	9	MD	Geochemical Surveys; Wheat 62-9	10–55	1955	9,000	Top Kreyenhagen 8,905. Bottomed in Oligocene.
22S	23E	27	MD	Angiola Oil Cc.; Douglas 1	12-28	1929	5,500	Etchegoin
22S	24E	15	MD	Federal Explor. Co.; Kinsella 1	8–26	1928	5,763	Temblor
22S	24E	15	MD	Herley, Jack; Tipton Comm. 1	8–49	1949	2,804	
22S	25E	25	MD	Union Oil Co.; Pacific States 76-25	3–43	1943	4,926	Miocene?
22S	26E	6	MD	Union Oil Co.; Reed 22-6	7–46	1946	3,931	Basement
22S	26E	8	MD	Union Oil Co.; Griffin 45-8	6–46	1946	3,746	Basement
22S	26E	10	MD	Porterville Oil & Gas Co.; No. 1	2–23	1927	2,200	Mariposa slate
22S	26E	11	MD	Tide Water Associated Oil Co.; Core Hole 87-11	9–43	1943	2,735	Basement?
22S	26E	15	MD	Magnet Oil Co. (Turner, L. E.); Turner Glaze 1	6–37	1938	3,282	Basement
22S	26E	21	MD	Franco Western Oil Co.; Drilexco-Cooper 28-21	9–54	1954	3,723	Top basement (schist) 3712
22S	26E	22	MD	Fortine, W. H.; Mosesian 1	6–36	1936	3,084	Jurassic?
22S	26E	23	MD	Jergins Oil Co.; Cloer 1	6–45	1945	2,867	Basement
22S	26E	30	MD	General Petroleum Corp.; Moran 42-30	11–46	1946	4,648	Basement
22S	26E	36	MD	Tejon Hills Company; McCloskey 1	4–55	1955	2,672	Top Santa Margarita 1765, top Round Mountain Equivalent 2085, top Olcese 2198
22S	27E	2	MD	Neaves Petroleum Developments; Boesch 1	10–54	1954	950	Top schist 864. Bottomed in granite
22S	27E	3	MD	Fruedenthal, Dowling, and Holt; Stoddard-Campbell 1	11–54	1954	988	Granite
22S	27E	4	MD	L. A. Gwynne & Associates; Sanborn 1	3–54	1954	1,323	Bottomed in weathered material overlying basement.
22S	27E	7	MD	Porterville Oil Syn.; No. 1	6–22	1925	1,947	Mariposa slate
22S	27E	8	MD	Navy Oil Co., Inc., Navy 2	8–54	1954	1,988	Bottomed in Miocene
22S	27E	9	MD	Navy Oil Co., Inc.; Navy 1	5–54	1954	1,197	Bottomed in Miocene. Est. 16 B/D 15 gravity oil from 875 to 1,015′ interval. Non-commercial
22S	27E	10	MD	Freudenthal, Dowling, and Holt; Adams 1	7–54	1954	1,126	3-ft. oil sand stringers at 835, 915, and 1,005. Bottomed in Miocene
22S	27E	10	MD	Webb & Armstrong; No. 1	9–30	1930	100	
22S	27E	11	MD	A. J. McGreevy; Dee 1	1–54	1954	869	Top basement 837
22S	27E	13	MD	Laguna Consol. Oil Co.; Michaelis 1	5–55	1955	635	Top of granite 630′
22S	27E	15	MD	Anthonian Drilling Co.; Blue Boy 1	9–54	1954	843	
22S	27E	15	MD	Roberts & Avery; Well 1	5–54	1954	901	15′ oil sand at 773′ and 10′ oil sand at 820′
22S	27E	15	MD	Roy M. Rhoads; Ross Gardner 1	5–54	1955	897	
22S	27E	15	MD	McVicker-Sailee Dev. Co.; McVicker-Sailee 1	7–55	1955	650	Basement

22S	27E	15	MD	Lewis, Paul M.; No. 1	8-30	1934	1,117	Mariposa slate or granite
22S	27E	15	MD	Pettingall, C. E.; Campo Verde 1	4-31	1931	955	
22S	27E	15	MD	Shannon Oil Co.; No. 1	8-24	1925	844	
22S	27E	16	MD	C. E. Stoner; Stoner 1	5-54	1954	975	Oil sand at 855′
22S	27E	16	MD	John Elrich; Elrich 1	10-55	1955	1,100	
22S	27E	16	MD	Andrews & Lancaster; Parish 1	5-54	1954	1,072	
22S	27E	17	MD	Maxwell & Associates; Maxwell 1	7-54	1955	1,184	
22S	27E	17	MD	Wesley H. Colquitt; C. & P. P. 1	1-55	1955	1,161	
22S	27E	17	MD	J. K. Wadley. (Corwin Drlg. Co.); Wadley 1	9-53	1954	1,946	Top conglomerate 1,859′
22S	27E	17	MD	Pioneer Dev. Co.; No. 1	7-24	1926	966	Tulare
22S	27E	17	MD	Pioneer Dev. Co.; No. 2	5-25	1928	1,290	
22S	27E	19	MD	Richfield Oil Corp.; Terra Bella Comm. 1-1	11-43	1943	2,353	Basement
22S	27E	20	MD	Knoop, Geo. C.; No. 1	4-31	1932	936	Mariposa slate
22S	27E	21	MD	Valley Oil Company; Culver 1	5-54	1954	1,094	Miocene
22S	27E	21	MD	Richey, R. R.; No. 1	9-30	1931	1,040	Mariposa slate
22S	27E	21	MD	Reid, Gene, Exploration Co.; Murray 1	8-46	1947	1,433	Basement
22S	27E	22	MD	Flintridge Oil Co.; St. Clair 2	8-54	1954	840	Miocene
22S	27E	22	MD	Flintridge Oil Co.; St. Clair 3	12-54	1954	928	
22S	27E	22	MD	Flintridge Oil Co.; St. Clair 1	5-54	1954	815	Miocene
22S	27E	22	MD	H. F. West; Hallain 2	4-54	1954	834	Miocene
22S	27E	22	MD	T. W. Stansbury; Gibson 1	1-55	1955	912	U. Miocene
22S	27E	22	MD	Page & Davis; Dunham 1	3-55	1955	874	Granite
22S	27E	22	MD	A. J. McGreevy, Rhoads 4	10-55	1955	978	Basement 942
22S	27E	22	MD	McGreevy-Neary Oil Co., Doe 1	12-53	1954	853	Miocene
22S	27E	22	MD	Congress Pet. Co. (Campbell, W. A.); No. 1	9-30	1930	854	
22S	27E	22	MD	Congress Pet. Co.; Congress 1	1-51	1951	1,212	Top granite 1,200
22S	27E	22	MD	Congress Pet. Co.; Congress 2	4-51	1952	1,167	Top granite 1,117
22S	27E	22	MD	Congress Pet. Co.; Congress 3	9-51	1952	1,115	Bailed oil and fresh water. Top oil sand 828
22S	27E	22	MD	Holly Dev. Co.; Murray 1	5-23	1926	1,115	Mariposa slate
22S	27E	22	MD	Holly Dev. Co.; Murray B-1	8-22	1926	1,200	
22S	27E	22	MD	Holly well	----	1925	1,130	
22S	27E	22	MD	McGreevy, A. J.; No. 1	10-53	Comp. 1953	988	Discovery well of Deer Creek field. IP 60 B/D oil from 736-914 of Chanac equiv. (Pliocene or Miocene)
22S	27E	22	MD	Shannon Oil Co.; No. 2	10-24	1924	430	Slate
22S	27E	23	MD	Reese, C. L.; Mavilo 1	8-53	1953	794	Buff claystone (Pleistocene ?) 718. Converted to water well.
22S	27E	23	MD	Reid, Gene, Exploration Co.; Miami 1	2-47	1947	815	Basement
22S	27E	23	MD	Terra Bella Drilling Co.; No. 1	10-30	1930	805	Granite (?)
22S	27E	24	MD	Hudson Oil Co.; Hudson-Faye 1	3-48	1950	3,666	
22S	27E	24	MD	Mid-Valley Corp.; Hudson-Faye 2	4-51	1951	814	Top granite 515
22S	27E	26	MD	Andrews & Lancaster; Staley 1	6-54	1954	717	Top weathered basement 532, top granite 690
22S	27E	26	MD	Hub Oil Co.; Halbert 1	5-25	1925	800	Mariposa slate
22S	27E	27	MD	McGreevy-Neary Oil Co.; T.B. I.D. 2	5-54	1954	1,048	Top basement 1,042

Exploratory wells drilled for oil and gas in Tulare County through 1955.—Continued.*

T.	R.	Sec.	B&M	Name of company and well	Date started	Date abandoned	Total depth (feet)	Geology (at bottom, unless otherwise indicated)
22S	27E	27	MD	Terra Bella, Ltd.; Montgomery 2	8–54	1954	807	Miocene
22S	27E	27	MD	Terra Bella, Ltd.; Montgomery 1	7–54	1954	1,100	Miocene
22S	27E	27	MD	Jacobson-Imperial Oil Co.; Short 1	8–54	1954	1,257	Top basement 1,247
22S	27E	27	MD	J. W. Douglas; Hornbrook 1	4–54	Comp. 1954	1,098	Deer Creek extension (?), 1 mile S.W. Initial prod. 22 B/D, 17 gravity oil from McVan Equivalent (M. Miocene). Producing interval 757-761′ & 777-781′. Well later abandoned.
22S	27E	27	MD	Chase Exploration; Hastings 1	6–55	1955	935	
22S	27E	27	MD	Cumming Pet., Ltd.; Hastings 1	9–30	1930	1,221	Mariposa slate
22S	27E	27	MD	Hub Oil Co.; No. 1	12–24	1925	1,488	Mariposa slate
22S	27E	27	MD	Hub Oil Co.; No. 2	8–25	1925	746	Mariposa slate
22S	27E	27	MD	Terra Bella Irr. Dist.; No. 33	1925	1925-1926	1,008	Mariposa slate
22S	27E	27	MD	Vincent Albano; Wiley 1	6–54	1954	849	
22S	27E	28	MD	Michael Cannata; Larson & Assoc. 2	1–55	1955	1,428	
22S	27E	28	MD	Michael Cannata; Larson & Assoc. 1	1–55	1955	1,372	Top slate 1,354
22S	27E	28	MD	Richfield Oil Corp.; Terra Bella-Hastings 1	11–43	1943	1,741	Basement
22S	27E	28	MD	Smith, J. L. and R. H. Larson; Moore 1	5–47	1947	1,437	Basement
22S	27E	29	MD	Richfield Oil Corp.; Terra Bella Adams 1	10–43	1943	1,920	Basement
22S	27E	32	MD	American Copper Company; Crow 1	12–54	1955	2,019	Top Mariposa slate 2,002
22S	27E	33	MD	L. P. Reischman; Henderson 1	6–54	1954	832	Top Vedder 795
22S	27E	34	MD	Verde Oil Co.; Janis 1	5–54	1954	1,385	Miocene
22S	27E	34	MD	Rhoads & Gilliam, Well 1	4–54	1954	896	Miocene
22S	27E	34	MD	Alexander, Ford, et al; No. 1	8–30	1931	1,000	Mariposa slate
22S	27E	34(?)	MD	Gholson, Fred N.; Chamboy 1	----	1935	915	
22S	27E	34	MD	Hallock, William A.; No. 1	8–30	1930	1,090	
22S	27E	34	MD	Jacques Oil Co.; No. 1	8–30	1930	680	Mariposa slate
22S	27E	34	MD	Rayatt Oil Corp.; Hinshaw 1	8–30	1930	1,085	Granite (?)
22S	27E	34	MD	Roetner Oil Co.; No. 1	10–30	1930	1,447	Slate (?)
22S	27E	34	MD	Roetner Oil Co.; (Turk-Campbell Pet. Co.); No. 3	9–30	1935	1,365	
22S	27E	34	MD	Sheldon & Gholson; No. 1	6–32	1935	900	
22S	27E	34	MD	Terra-Bella Drill. Co., Ltd.; Keen 1	8–30	1930	1,243	Basement
22S	27E	34	MD	Terra-Bella Drill. Co., Ltd.; Russling 1	7–30	1930	924	
22S	27E	34	MD	United Kern Pet., Inc., Ltd.; No. 1	9–30	1931	1,198	Slate (?)
22S	27E	34	MD	United Kern Pet., Inc., Ltd.; Clair 1	--	1931	1,170	
22S	27E	35	MD	Navy Oil Co.; Navy 1-A	5–54	1954	1,124	Top weathered granite 1,067, hard granite 1,102
22S	27E	35	MD.	Fleetwood Oil Co.; Gardner 6	2–54	1954	921	
22S	27E	35	MD	McK. Butler & Associates; Norwood Rancho 1	5–55	1955	758	

22S	27E	35	MD	Consolidated Properties; Gardner 1	7-30	1930	1,003	Mariposa slate
22S	27E	35	MD	Norwood Oil Co. (Terra Bella Oil Co.); Gardner 1	11-29	1930	916	Discovery well of Terra Bella area
22S	27E	35	MD	Norwood Oil Co.; Gardner 5	6-52	1952	1,020	Top granite 1,019. Trace of oil
22S	27E	35	MD	Norwood Oil Co. (Consolidated Properties); Hopkins 1 (was No. 2)	8-30	1930	912	Abandoned oil producer
22S	27E	35	MD	Sheppard, Dan & Assoc.; No. 1	10-38	1938	956	Pliocene
22S	27E	35	MD	Stout, George W.; Stout 1	5-41	1941	1,135	Basement
22S	27E	35	MD	Western Oil & Expl. Co.; Gardner 1	7-30	1935	1,022	Granite. Abandoned oil producer
22S	28E	30	MD	Cole Oil Co.; Cole-Baker 1	1-53	1953	352	Granite wash 280, hard granite 310
23S	23E	7	MD	Trico Oil & Gas Co.; Calif.-West. 1	8-36	1936	3,184	Etchegoin
23S	23E	7	MD	Western Nat. Res. Corp.; Guess 3	4-32	1933	1,832	Tulare
23S	23E	20	MD	Bender & Dunlap; Roller 1	10-49	1949	3,065	Top Mya 2,960, base Mya 3,050
23S	23E	27	MD	Geochemical Surveys; Well 36-27	1-54	1954	3,700	Converted to water well. Top Mya sand 2,758′, top Atwell Island sand 3,534′
23S	23E	27	MD	Lloyd Harnish Assoc.; Well 72	6-54	1954	2,846	1st Mya sand 2,720′, top 2nd Mya sand 2,799′
23S	23E	32	MD	Pacific Central Oil Co.; Finch 14	5-46	1946	3,416	
23S	23E	33	MD	E. P. Jennings; No. 2	7-37	1937	2,788	
23S	24E	32	MD	Sequoia Oil & Gas Co. (Sidney M. Biddell); Phillips-Sequoia 1	6-53	1953	3,843	1st Mya 2,700. Bottomed in Pliocene
23S	25E	1	MD	Shell Oil Co.; Parson 36-1	5-45	1945	5,485	Basement
23S	25E	9	MD	Continental Oil Co.; Pixley Comm. 1	2-42	1942	7,906	Basement
23S	25E	15	MD	Continental Oil Co.; Reynolds 1	7-42	1942	5,847	Miocene
23S	25E	22	MD	Pixley Dev. Co.; No. 1	7-23	1925	1,450	Etchegoin
23S	26E	8	MD	Compass Oil Co.; Compass 1	9-39	1939	4,322	Basement
23S	26E	8	MD	Obsorne, P. H.; No. 1	9-29	1931	4,773	
23S	26E	13	MD	Reid, Gene, Explor. Co.; Mayo 1	6-47	1947	3,456	Basement
23S	26E	16	MD	Barnsdall Oil Co.; Lombardi-Security 1	5-44	1944	4,223	Basement
23S	26E	16	MD	Seaboard Oil Corp.; Security 1	12-36	1937	4,127	Miocene
23S	26E	17	MD	Jergins Oil Co.; C. G. L. 84	10-48	1948	4,398	Basement
23S	26E	17	MD	Jergins Oil Co.; Calif. Grape 18	7-45	1945	4,635	Basement
23S	26E	18	MD	Kern Oil Co., Ltd.; Deer Creek 81	7-51	1951	4,600	Top Pyramid Hills sd 3,890. Bottomed in L Vedder
23S	26E	22	MD	Superior Oil Co.; Day 24-22	2-47	1947	4,173	Basement
23S	26E	29	MD	Shell Oil Co.; Sunnyvale Comm. 14-1	5-46	1946	4,825	Basement
23S	27E	3	MD	Bowles, Dr., et al.; No. 1	1-25	1926	1,631	
23S	27E	3	MD	Gholson, Fred N.; Chamboy 1	4-31	1931	1,300	Granite (?)
23S	27E	4	MD	American Copper Company; American-Padula 1	12-54	1955	1,700	Top Mariposa slate (?) 1,666
23S	27E	10	MD	Baker-Grover Co.; Baker-Grover 1	11-33	1935	1,606	Mariposa slate
23S	27E	10	MD	Baker-Grover Co.; Baker-Grover 1-A	2-35	1935	1,030	Mariposa slate
23S	27E	11	MD	Continental Development Corp.; 1-11-2	2-44	1944	.779	Non-marine
23S	27E	11	MD	Larson, I. H. & Stanford, M. A.; No. 1	7-30	1930	1,200	
23S	27E	11	MD	Larson, I. H. & Stanford, M. A.; No. 2	9-30	1930	15	
23S	27E	11	MD	Miller & Sullivan; No. 1	9-30	1934	1,071	Mariposa slate
23S	27E	11	MD	Stout, George W.; Stout 2	8-41	1942	745	Miocene

Exploratory wells drilled for oil and gas in Tulare County through 1955.—Continued.*

T.	R.	Sec.	B&M	Name of company and well	Date started	Date abandoned	Total depth (feet)	Geology (at bottom, unless otherwise indicated)
23S	27E	12	MD	Kabella Oil Co.; H. A. Briggs 1	3–35	1936	800	Jurassic
23S	27E	12	MD	Kabella Oil Cc.; H. A. Briggs 2	11–35	1936	903	Jurassic
23S	27E	15	MD	C. H. Olsson; Mueller 2	4–55	1955	900	
23S	27E	15	MD	C. H. Olsson; Well 1	2–55	1955	1,554	
23S	27E	17	MD	Tannehill, L. B.; Hunsaker 1	9–44	1944	2,330	Basement
23S	27E	18	MD	J. L. Smith; Crow 1	5–55	1955	1,803	Top Santa Margarita 1,200, top Olcese 1,800
23S	27E	22	MD	Reid, Gene, Drilling Co.; Wing 1	4–46	1946	2,321	Basement
23S	27E	22	MD	Tannehill, L. B.; Tannehill 1	7–44	1944	1,688	Basement
23S	27E	29	MD	Lamb, J. O. (Ducor Drlg. Co.; Big Four Oil Syn.); No. 1	10–22	1932	4,330	Mariposa slate
23S	28E	5	MD	Arnold, V. F.; Terra Bella Irr. Dist. 1	2–41	1944	255	Basement
23S	28E	7	MD	Hagerty & Caine, Trustees; No. 1	8–30	1931	734	Slate (?)
23S	28E	7	MD	Smith, J. L. & R. H. Larson; Smith 1	1–47	1947	592	Basement
23S	28E	7	MD	Southard, M. W.; R. & M. 1	3–42	1942	674	Basement
23S	28E	7	MD	Southard, M. W.; Core Hole 1	2–42	1942	360	
23S	28E	8	MD	Grand View Oil Co., Ltd.; No. 1	1–31	1931	(?)100	Granite (?)
23S	28E	8	MD	Jennings Syn.; McMasters 1	9–30	1931	530	Mariposa slate
23S	28E	9	MD	Arnold, V. F.; Yellow King 1	12–38	1944	683	Basement
23S	28E	17	MD	Terra-Bella Irr. Dist.; No. 1	7–32	1933	442	Tulare
23S	28E	29	MD	Berghofer, Lypps & Le Mohm; No. 1	10–30	1931	1,142	Slate
23S	28E	31	MD	Griggs & Sumter; May 1	9–35	1937	1,500	Basement
24S	23E	4	MD	E. P. Jennings; No. 1	7–36	1937	2,707	
24S	23E	9	MD	Elmer C. Von Glahn; Sawyer 1	10–54	1954	3,700	Top 1st Mya 2,660, top Atwell Island 3,460. Bottomed in Pliocene
24S	23E	11	MD	Gravity Exploration Co.; Hudson-Buck-Jennings 1	3–32	1932	1,912	
24S	23E	11	MD	R.W.B. Gas & Oil Co.; R.W.B. 1	3–40	1940	2,676	
24S	23E	16	MD	Fullerton Oil & Gas Co.; Union Central Life Insur. Co. 1	8–54	1954	11,626	Top 1st Vedder 10,205, top 4th Vedder 10,652, top Famosa 11,615
24S	23E	23	MD	Harry H. Magee, Oper.; Wilbur 1	7–51	1951	4,300	
24S	23E	26	MD	Union Oil Co.; Daniel 43-26	8–54	1954	11,465	Top 1st Mya 2,500, top Vedder 10,163, top Famosa 11,385
24S	23E	30	MD	Pacific Central Oil Co.; No. 16	12–46	1946	3,500	
24S	24E	9	MD	Geochemical Surveys; Covey 77-9	8–55	1955	3,801	Top 1st Mya 2,540′, top Mulinia 3,710. Bottomed in Pliocene

24S	24E	10	MD	Geochemical Surveys; Bendetti 77-10	6–54	1954	7,238	Top Mya sand 2,460, Reef Ridge 6,000′, Stephens sand 6,586, top Valv sand 6,753, McVan sand 6,842, top Olcese 7,077′ Bottomed in Olcese
24S	24E	12	MD	Ohio Oil Co.; Jack C. Phillips, Jr. 1	12–53	1954	9,464	Top Olcese 6,298, top Eocene 7,877, top basement 9,463
24S	24E	22	MD	Mitchell, W. R.; No. 1	4–23	1925	3,805	
24S	24E	26	MD	Grafford, J. W.; No. 19	1–27	1930	2,530	
24S	24E	26	MD	Ozena Oil Co.; No. 1	9–26	1927	2,300	
24S	24E	28	MD	Trico Oil & Gas Co.; Well 28-1	9–49	1949	4,007	Top 1st Mya 2,536, top Cutter sd equiv. 3,224, top Atwell Island sd 3,290, bottomed in San Joaquin clay
24S	24E	29	MD	Caminol Co., Ltd. (Magnet Oil Co.); Amalgamated 1-9	8–37	1939	9,641	
24S	24E	35	MD	Walkin, John; Walklin-Delano 19	11–26	1930	478	
24S	25E	13	MD	Pacific Central Oil Co.; Divizich 1	3–47	1947	5,636	L Miocene
24S	25E	16	MD	Pacific Western Oil Corp.; Pacific Western-Brunner B-1	10–47	1947	7,462	Eocene?
24S	26E	1	MD	Texas Co.; Graham-Loftus 77-1	8–41	1941	3,537	Basement
24S	26E	20	MD	Humble Oil & Ref. Co.; Di Giorgio Fruit Corp. 1	11–48	1948	5,119	Basement
24S	26E	20	MD	Humble Oil & Refining Co.; McKevitt-Di Giorgio 1	3–49	1949	5,484	McVan 3,649, U Olcese 3,997, L. Olcese 4,404, Freeman 4,695, Pyramid Hills 4,765, Vedder 4,950, basement 5,479
24S	26E	24 or 25	MD	Dil-Harp Oil Co., Ltd.; Dil-Harp 1	3–33	1933	1,320	Some oil shows
24S	26E	24 or 25	MD	Dil-Harp Co., Ltd.; Dil-Harp 1-A	8–33	1933	1,134	
24S	26E	30	MD	Humble Oil & Refining Co.; Di Giorgio Fruit Corp. 2	12–43	1949	6,168	McVan 4,127, U Olcese 4,272, L Olcese 4,698, Freeman-Jewett 4,979, Pyramid Hills 5,040, Vedder 5,232, Famosa 5,638, basement 5,829
24S	27E	1	MD	Ducor Oil Co. (Crusaders Oil Co.); Muller 1	1–38	1939	1,463	Basement
24S	27E	5	MD	McCarthy Oil & Gas Co.; Smith 1	2–49	1949	2,494	Top Pyramid Hill (Vedder equivalent) 2,140, top granite 2,490
24S	27E	12	MD	Philadelphia Oil Co.; Kenda-Bryce 1	4–55	1955	1,384	Top schist 1,352
24S	27E	13	MD	Hub Oil Co.; Bryce 1	1–25	1925	1,623	
24S	27E	13	MD	Troutt, R. E.; Veach 1	12–48	1948	1,516	Basement?
24S	27E	14	MD	Kenwood Pet. Corp.; Kenwood 1	12–35	1936	1,589	
24S	27E	14	MD	Sievers, George (Ducor Pet. Co.; Resser, Wm. C.); Zimmerman 1	2–30	1936	2,154	

Exploratory wells drilled for oil and gas in Tulare County through 1955.—Continued.*

T.	R.	Sec.	B&M	Name of company and well	Date started	Date abandoned	Total depth (feet)	Geology (at bottom, unless otherwise indicated)
24S	27E	22	MD	Amerada Pet. Corp.; Jasmine Core Hole D	5–38	1938	2,068	
24S	27E	22	MD	Vedder Bros., Inc.; Hart 1	8–29	1930	2,320	
24S	27E	23	MD	Amalgamated Oil & Gas Corp.; Konda 5	2–39	1939	1,912	Basement
24S	27E	23	MD	Amalgamated Oil & Gas Corp.; Konda 6	4–39	1939	2,072	Basement
24S	27E	25	MD	Collins, James F.; Konda Core Hole 1	2–40	1940	1,654	
24S	27E	25	MD	White River Expl. Co.; Konda 1	5–41	1941	2,014	Basement
24S	27E	26	MD	Continental Oil Co.; Konda 1	4–52	1952	2,014	Top Olcese 1,087, top slate 2,005
24S	27E	26	MD	Continental Oil Co.; Konda 2	9–52	1952	2,250	Top Pyramid Hills 1,790, top U Vedder 1,883, top L Vedder 2,050, top Walker 2,135, top slate 2,245
24S	27E	27	MD	Kern Oil Co., Ltd.; Lubking 14	11–53	1953	2,638	Top granitic basement 2,584
24S	27E	29	MD	Terminal Drilling Co.; Schmidt-Cleaver 1	10–50	1950	3,222	Freeman-Jewett (L Miocene) 1,020, top Vedder ss 2,961, bottomed in L Vedder
24S	27E	34	MD	Pac. Oil & Gas Dev. Corp.; Burum-Wallace 1	5–55	1955	2,339	Top Pyramid Hills 1,953, top Vedder 2,118, top weathered basement 2,230′, top hard granite 2,337′
24S	27E	34	MD	Lomi Oil Corp.; Burnell 1	4–44	1944	2,510	Basement
24S	27E	34	MD	Reid Dev. Co.; No. 1	----	1911	2,424	
24S	27E	35	MD	Amerada Pet. Corp.; Jasmine Core Hole B	4–38	1938	2,122	
24S	28E	9	MD	Olsson, C. H.; Menne-Flynn 2	11–53	1954	400	Basement
24S	28E	10	MD	Olsson, C. H.; Menne-Flynn 1	11–53	1954	339	Basement
24S	28E	16	MD	Frank & Thomas Cannella; Exploration 1	3–49	1949	450	
24S	28E	17	MD	Sears, Wm. A. (Johnston, H. T.); No. 1	7–24	1928	1,015	
24S	28E	18	MD	J. Glen & Juliett Crist; Minnie 1	5–50	1950	1,201	Granite 1,195
24S	28E	20	MD	Frank & Thomas Cannella; Exploration 2	2–50	1950	567	Blue clay
24S	28E	27	MD	K. H. Kruse; Well 1	7–54	1954	502	Bottomed in broken schist
24S	28E	28	MD	Skay Exploration, Ltd.; Skay 2	8–54	1954	884	Top basement complex (slate) 815. Converted to water well
24S	28E	29	MD	Baringer, Corbridge & Gould; Sears 2	4–38	1938	860	Pliocene
24S	28E	29	MD	Wilcox, John F.; Sears 1	10–37	1937	887	
24S	28E	35	MD	San Joaquin Assoc.; Bowen 1	7–53	1953	882	Cherty slate

* Information on wells drilled prior to 1954 was obtained from California Div. Mines Special Rept. 45; later information is from California Div. of Oil and Gas Summary of Operations for 1954 and 1955 and Munger Oil-o-gram annual reports for 1954 and 1955.

PHOTO 44. Pumping jack and tanks at the Deer Creek oil field. *Photo by Mary Hill.*

Deer Creek Oil Field. The Deer Creek oil field is located about 1½ miles north of the Terra Bella area in sections 22 and 27, T. 22 S., R. 27 E., M.D. Although W. A. Campbell's well No. 2 (now Congress Petroleum Company's well No. 1) produced a little oil as early as 1930 from a location half a mile north of the present limit of the Deer Creek field, credit for the discovery of the field is given to the J. A. McGreevy well "Rhoads" 1 (now Southwest Foundation well "Rhoads" 1) located in SE¼ section 22. This well was completed in December 1953, pumping initially 20 barrels of oil and 150 barrels of water per day from 82 feet of oil sand between 736 and 914 feet. The productive formation is reported as the Chanac equivalent of Miocene or Pliocene age (Pierce 1953, p. 85).

During 1954, the Deer Creek area was the scene of an active drilling campaign and, of 26 wells drilled, 7 were completed in lenticular sands at shallow depth. One of these wells, the J. W. Douglas well "Hornbrook 1," located in the SW¼ section 34, T. 22 S., R. 27 E., M.D., was completed in what is reported to be the McVan equivalent (middle Miocene) and was considered an extension of the Deer Creek field (Munger Oil-o-gram, 1954, p. 21). Initial production was 22 barrels of oil per day from the intervals 757-761 and 777-781 feet, but the well has since been abandoned. Drilling activity decreased in 1955 and 1956, only four wells being completed in each of these years. About 19 wells had been completed by the end of August 1957, and during that month 18 wells were producing at a rate of 10.4 barrels of 16.5° gravity oil and 53 barrels of water per day per well. The field currently (October 1957) measures 1 mile in length by a quarter of a mile in width, but the limits have been only partially defined. The type of accumulation has not been definitely determined, but it is believed that production is obtained from lenticular sands from formations

variously reported to be Chanac (upper Miocene to lower Pliocene), McVan equivalent (middle Miocene), and Walker (upper Eocene to lower Miocene).

Production in 1956 was 54,038 barrels of oil with an estimated value of $116,000. Cumulative production to the end of 1956 was 168,944 barrels. According to L. P. Stockman (1957, p. 44), reserves as of January 1, 1957 were estimated to be 361,000 barrels of oil.

Lindsay Area. Some excitement was caused in 1951 when the presence of oil was detected in a water-observation well drilled by the U. S. Bureau of Reclamation near Lindsay in the center of section 24, T. 20 S., R. 26 E., M.D. The well was drilled to a depth of 1,071 feet. The oil was along fractures in an altered tuff taken from a cored interval between 1,047 and 1,058 feet. Four exploratory wells were subsequently drilled in the area, but without success. One of these wells, drilled to 1,187 feet by Shell Oil Company, was located about 100 feet from the original observation well.

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LIST OF MINES

The following table lists lead and zinc mines in alphabetical order by county. The number in the first column refers to the location on the accompanying map, Economic Mineral Map of California number 7, in the pocket of this volume.

The notation as to ''class'' and ''type'' refers to the total production and chief mineral products, as defined on the map.

References given in the *Remarks* column refer to the bibliography accompanying this report. Only the last name of the author is given. The first number following the author's name is the abbreviated date of publication as cited in the bibliography; the second number, that following the colon, is the page reference.

ANTIMONY

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Bearhive	J.J. Davis, Mineral King (1930)	Appr.	17S	31E	MD	Stibnite deposit 4 mi. south of Mineral King in the Kaweah quadrangle (Franke 30:431).
	Lady Alice	Not determined	Appr.	17S	31E	MD	Located 1/4 mi. south of Mineral King on the west slope of East Fork Kaweah River, in the Kaweah quadrangle. A 2-ft. quartz vein striking N. 10° W. and dipping 50° S. in slate is mineralized by stibnite. Developed by a series of prospect pits along strike. No known production. (Franke 30:431; Hamilton 20:257; Tucker 19:904.)

CHROMITE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
1	Bowlin	Gill Bros. Cattle Co.	NW$\frac{1}{4}$20	19S	27E	MD	Located 4 mi. north of Lindsay in the Rocky Hill quadrangle. Two lenses of ore, one above other, in fractured serpentinized dunite. Leased in 1916 to Lee Bowlin who mined 100 tons of massive shipping grade ore from an open cut 60 ft. long, 6 ft. deep and 2 to 6 ft. wide. Inactive since World War I. (Hamilton 20:258; Rynearson 48:96-97; Tucker 16:906.)
2	Earl Smith	Gill Bros. Cattle Co.	S$\frac{1}{2}$20 NW$\frac{1}{4}$28	19S	27E	MD	Located 4 mi. north of Lindsay in the Rocky Hill quadrangle. Reported production of 250 tons from open cuts in three lenses about 100 ft. apart, by lessee Earl Smith, 1916-18. Inactive since. (Rynearson 48:97; Toll 18.)
3	Gill	Gill Bros. Cattle Co.	SE$\frac{1}{4}$22	19S	27E	MD	Located about 1/2 mi. southwest of Gill Ranch house; Rocky Hill quadrangle. Vertical lens of chromite in serpentinized dunite. Explored by 90 ft. of adits and crosscuts and three raises to surface. Amount of ore produced during World War I not known. Inactive since. (Rynearson 48:97.)
4	Gill Ranch	Gill Bros. Cattle Co.	SE$\frac{1}{4}$ NW$\frac{1}{4}$16	19S	27E	MD	Located at south end of Yokohl Valley in the Rocky Hill quadrangle. (Rynearson 48:96; Toll 18; herein.)
5	Holston (Vaughn, Vaughn Ranch)	Mrs. Charles Holston	S$\frac{1}{2}$9	22S	28E	MD	Located in extreme southwest corner of Kaweah quadrangle 4 mi. southeast of Porterville on the slope of ridge north of Dry Creek. (Bradley 18:104,213, 225; Franke 30:432; Laizure 23:523; Rynearson 48:98; Tucker 16:907; herein.)

CHROMITE, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
6	James	Mrs. J. H. James	$S\frac{1}{2}$11	21S	27E	MD	Located 4 mi. north of Porterville in the Porterville quadrangle. Total production 175 long tons between 1915-16. Deposit assumed to be depleted in 1916. (Rynearson 48:98; Tucker 17:907.)
7	Lewis Hill	Not determined	$SW\frac{1}{4}$ $NW\frac{1}{4}$13	21S	27E	MD	Located on south spur of Lewis Hill, 2 mi. north of Porterville in the Porterville quadrangle. Production not known. (Herein.)
8	Sattlefield	Gill Bros. Cattle Co.	$NW\frac{1}{4}$20	19S	27E	MD	Located 6 mi. north of Lindsay in the Rocky Hill quadrangle. Total production 75 long tons from north-trending lenses 2 to 5 ft. wide. Workings consisted of two open cuts. (See also Bowlin.) (Rynearson 48:97; Tucker 16:906.)
	Vaughn						See Holston (Bradley 18:104,225).
	Vaughn Ranch						See Holston.
9	Waddell	Gill Bros.Cattle Co.	$SW\frac{1}{4}$17 $NW\frac{1}{4}$20	19S	27E	MD	Located 4 mi. northeast of Lindsay in the Rocky Hill quadrangle. Two similar deposits of narrow lenses of chromite trending northeast in serpentine were mined under lease in 1916-17. Total production was 110 long tons. The deposits were assumed to be depleted in 1917. (Bradley 18:213,225; Franke 30:432; Rynearson 48:97; Tucker 16:907.)

COPPER

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
10	Annie Fox	A. Crowley, T.J. Crabtree and W.F. Cord, Mineral King (1930); leased to Interstate Industrial and Transportation Co., W.T. Perry, Tulare (1930)	14	17S	31E	MD	Claims in the Mineral King district on the west slope of ridge east of the East Fork Kaweah River, at an elevation of 8000 feet in the Kaweah quadrangle. Chalcopyrite and pyrite in veins striking N. 30° W., dipping 70° N. over a 5- to 20-ft. zone along a limestone-slate contact. Gossan caps the deposit. Developed by prospect shafts and tunnels. No known production. (Eric 48:352; Franke 30:434; Tucker 19:908.)
	Barber						See Barber-Witt.
11	Barber No. 1	Not determined	14	23S	28E	MD	Copper prospect 3 mi. north of Fountain Springs in the White River quadrangle. (Aubury 05:236; 08:290; Eric 48:352.)
12	Barber No. 2	Not determined	19	21S	29E	MD	Copper prospect 1 mi. north of Success in the Kaweah quadrangle. Gossan in diabase and amphibolite schist. (Aubury 05:236; 08:290,292; Eric 48:352.)
13	Barber-Witt (Barber)	Not determined	9(?)	20S	31E	MD	On ridge south of North Alder Creek, northeast of Camp Wishon in the Kaweah quadrangle. Chalcopyrite and pyrite in east-striking vein on contact between granodiorite and porphyry. Developed by a 50-ft. tunnel and series of prospect pits along vein. (Eric 48:352; Tucker 19:908.)
	Black Prince						See under gold-silver.

COPPER, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Blue Crystal	Not determined	Appr.	20S	27E	MD	Copper prospect; narrow vein in serpentine developed by 70-ft. adit. See also Gill (?). (Aubury 08:293; Eric 48:352.)
	Cedar Hill						See under zinc-lead (Eric 48:352).
	Copper Mountain	Not determined	Appr.	14S	31E	MD	Copper prospect near Elizabeth Pass in the Tehipite quadrangle. A northeast-trending belt of metasedimentary rocks containing copper-bearing zones. Developed by an 18-ft. shaft, 50-ft. tunnel, and open cuts. A 3-ft. zone of carbonate ore developed by the shaft in 1900. High copper assays reported; also gold. See also Copper Queen (?). (Aubury 05:236; 08:292; Eric 48:352; Tucker 17:909.)
	Copper Queen	Not determined	25(?)	15S	31E	MD	Located near Elizabeth Pass in the Tephipite quadrangle. Possibly same as Copper Mountain or Oakland Copper. Copper mineralization reported in a zone 150 ft. wide, striking northeast. (Crawford 94:70; Eric 48:352.)
	Deer Creek Silver	Deer Creek Silver Mining Co. 1330 L St. Bakersfield (1922)	Appr.	22S	28E	MD	Located 6 mi. east of Magnolia, in the White River quadrangle; elevation 500-600 ft. Copper-silver-gold prospect along shear zone which strikes north, dips 50° W in granite. Developed by shafts, drifts, and crosscuts. Reported to have shipped ore prior to 1880, last active in 1922. (Franke 30:462; Laizure 23:537-538.)

COPPER, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Dewey	Not determined	32	19S	31E	MD	Copper prospect northeast of Camp Wishon in the Kaweah quadrangle. Possibly same as Powell. (Aubury 05:236; 08:292; Eric 48:352.)
	Gill	Not determined	Appr.	20S	27E	MD	Possibly same as Blue Crystal. Copper prospect on a 2-ft. vein; 90 ft. of development workings. (Aubury 08:293; Eric 48:352.)
14	Gram	Paul Gram; leased to E.A. Orton, J. Shaw, and J. Racker (1930)	3	20S	27E	MD	Located 4 mi. east of Lindsay in Round Valley in the Lindsay quadrangle. Copper prospect developed by a 75-ft. shaft. (Eric 48:352; Franke 30:435.)
	Grider	Not determined	31	19S	31E	MD	Prospect. Test lots of ore shipped prior to 1905. (Aubury 05:234; 08:290; Eric 48:352.)
15	Hamilton	Hamilton Ranch, Yokohl (1956)	NE¼ SW¼33	18S	27E	MD	(Eric 48:352; Tucker 19:908; herein.)
	Hart group						See Hart prospects (Eric 48:352).
16	Hart prospects (Hart group)	W.H. and H.M. Hart, and L.N. Badger	2	15S	28E	MD	Reached via 3-mi. trail from upper end of Redwood Canyon. Located in the Tehipite quadrangle at an elevation of 4700 ft. Copper-gold-silver in veins striking northwest dipping 70° N. along limestone and schist contact. Developed by shallow cuts only. Contact zone more recently of interest for tungsten. See Redwood Canyon Tungsten. (Eric 48:352; Franke 30:435.)

COPPER, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
17	Iron Capping	Not determined	16	20S	31E	MD	Located 16 miles northeast of Springville at 7100 ft. elevation. A 200- by 500-ft. gossan prospected by 4- to 6-ft. pits which disclosed a complex sulfide body containing pyrite, chalcopyrite, galena, and sphalerite. (Eric 45:352; Tucker 19:951.)
	Keller	Not determined	Appr.	19S	31E	MD	Copper prospect in the Camp Wishon area in the Kaweah quadrangle (Aubury 05:236; 08:290; Eric 48:352).
	Kern-Sierra						Chalcopyrite in contact zone. See under tungsten.
	Kirkland	Not determined	2	15S	28E	MD	Copper prospect near Big Spring in the Tehipite quadrangle (Eric 48:352; Laizure 23:523).
	Lady Franklin						See under zinc-lead (Eric 48:353),
18	Lions Nest	Not determined	14	17S	31E	MD	Located in the Mineral King district south of the Annie Fox. Copper-bearing zone on contact between limestone and slate striking N. 10° W., dipping 70° NE. A 400-ft. adit was abandoned before reaching the mineralized zone. The adit is caved. (Eric 48:353; Tucker 19:909.)
19	Mankins	Not determined	23	19S	28E	MD	Location 9 mi. east of Exeter on Yokohl Creek in the Kaweah quadrangle. Copper reported along a 4-ft. zone. (Crawford 94:70; Eric 48:353.)

COPPER, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
20	Oakland Copper	Not determined	25	15S	31E	MD	Near Elizabeth Pass in Tehipite quadrangle. Bornite, chalcopyrite, and pyrite on limestone-granite contact. Developed by an 80-ft. shaft, 70-ft. tunnel, 30-ft. tunnel, and open cuts 5 ft. deep. Zone reported to be 80 ft. wide. See also Copper Queen (?). (Eric 48:353; Tucker 19:909.)
21	Page	Not determined	17	18S	26E	MD	Venice Hills, Exeter quadrangle. A 4-ft. siliceous vein with copper and some gold. (Crawford 94:297; 96: 64; Eric 48:353; Tucker 19:909.)
22	Powell	National Copper Co., Bakersfield (1956)		19S	31E	MD	Located on the North Fork of Middle Fork of the Tule River about 4 mi. north of Camp Wishon. Contact metamorphic deposit. Pyrite, chalcopyrite, pyrrhotite, galena, and sphalerite in fracture zones in interbedded limestone, schist, slate, and quartzite. Gangue minerals include garnet, epidote, hornblende, actinolite, feldspar, calcite, and quartz. Scheelite present in some of the workings. Prospects developed by two shallow shafts and three adits. (Aubury 05:234; 08:290; Eric 48:353; Franke 30:435-438; Tucker 19:909-910.)
23	Round Valley Copper	C.H. Cannon, Lindsay	SE$\frac{1}{4}$ SE$\frac{1}{4}$3	20S	27E	MD	Located in Round Valley $2\frac{1}{2}$ miles east of Lindsay in the Lindsay quadrangle (Eric 48:352; Tucker 19:910; herein).
24	Thomas Jacobs	Not determined	15	18S	26E	MD	Located at the southeast end of Venice Hills, 4 miles southwest of Woodlake in the Exeter quadrangle. Copper prospect developed by two 40-ft. shafts. (Franke 30: 439.)
	Tornado	Fred Maxon, Three Rivers (1930)	Appr.	18S	30E	MD	Copper prospect reported near Clough Cave on South Fork Kaweah River, in the Kaweah quadrangle. Developed by 20-ft. shaft. (Franke 30:439.)

GOLD

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Adams Flat	Not determined	9(?)	16S	27E	MD	Gold placer in Adams Flat in the Dunlap quadrangle (Crawford 94:295; 96:469).
	Agnes Fletcher	Not determined	28(?)	18S	27E	MD	Located 1 mile east of Yokohl in the Rocky Hill quadrangle. A 30-in. quartz vein dipping 45° E. was explored by an open cut and shaft. (Crawford 96:469.)
	Ante-Up	Not determined	Appr.	24S	27E	MD	Pius Canyon in the White River quadrangle. A 6-in. quartz vein in granite explored by a 12-ft. shaft. (Crawford 94:295; 96:469.)
	Bald Mountain	Not determined	27(?)	24S	29E	MD	Bald Mountain, $1\frac{1}{2}$ mi. southeast of White River at 2000-ft. elevation. Original eight claims on quartz vein striking east, dipping 80° N. in granite. Maximum width of vein 4 ft.; 4- to 12- inch ore shoot contained free gold and auriferous pyrite. Developed by shafts 262 and 200 ft. deep, with levels at 157 ft., 190 ft., 257 ft. Total underground workings about 2700 ft. (Crawford 94:295; 96:469; Tucker 19:912-913.)
25	Barton	Not determined	21	15S	26E	MD	Located on Rattlesnake Creek $2\frac{1}{2}$ mi. northwest of Aukland at 1600-ft. elevation in the Dunlap quadrangle. Free gold in a 3-ft. vein striking north, dipping 75° E. in granite. Developed by a 350-ft. adit with winze to the 100 level; also a 220-ft. adit. (Crawford 94:295; 96:469; Franke 30:441; Laizure 23:527; Tucker 19:912-913.)

GOLD, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Billy Brown	Not determined	Appr.	20S	28E	MD	Fraizer Valley, 8 mi. northeast of Porterville in the Kaweah quadrangle. An 8-in. quartz vein in granite was developed by a 100-ft. inclined shaft, and four adits. Ore milled in a horse-powered arrastre. (Crawford 96:469.)
	Black Prince	Not determined		14S	28E	MD	Located in Redwood Canyon 6 mi. southeast of Badger at 2600-ft. elevation, in the Tehipite quadrangle. A 5-ft. zone of garnet rock in sheared slate contains gold, silver, and copper. Developed by a 50-ft. shaft and 150-ft. tunnel. (Crawford 94:296; 96:469,611.)
	Blue Bird	Not determined		14S	28E	MD	Located 6 mi. east of Camp Badger in Redwood Canyon; elevation 2700 ft. A siliceous vein 4 ft. wide in sheared slate; developed by 60-ft. and 200-ft. adits. (Crawford 94:296.)
	Blue Mountain	Not determined					Although previously reported to be in Tulare County, this deposit actually is in Kern County (Crawford 94:296; 96:469).
	Bob Allen (General Grant)	Not determined					On Slate Mountain 5 mi. southwest of White River at 1420-ft. elevation. An 18-in. vein dipping 60°N. in slate developed by a 24-ft. and 31-ft. shaft and an 80-ft. tunnel. This deposit may be in Kern County. (Crawford 96:469.)

GOLD, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Cherokee	Not determined		17S	31E	MD	Located 2 mi. Southeast of Mineral King on ridge and on East Fork Kaweah River in the Kaweah quadrangle; elevation 10,600 ft. Three claims on a 12-in. vein striking northwest, dipping 60° N., containing auriferous arsenopyrite. Developed by a 20-ft. shaft and 25-ft. tunnel (Franke 30:441; Laizure 23:527; Tucker 19:913.)
	Clara Gibbons	Not determined					Located 3 mi. southeast of White River in Chileno Gulch; elevation 1610 ft. A 6-in. to 2-ft. quartz vein dipping 45° SE. in granite contains gold, pyrite, and galena. Developed by a 90-ft. inclined shaft, a 125-ft. crosscut, and 100-ft. drift. (Crawford 94:296; 96:469.)
	Coarse Gold	Not determined	S½28	24S	29E	MD	Located ½ mi. south of White River at an elevation of 1240 ft. in the White River quadrangle. A 4-ft. vein dipping 85° S. between granite and diabase. Developed by a 55-ft. shaft with 40- and 50-ft. drifts. (Crawford 96:469.)
	Creeks	Not determined	Appr.	21S	29E	MD	Located on northeast slope of Cow Mountain, 13 mi. east of Porterville at 2680-ft. elevation, in the Kaweah quadrangle. A series of narrow parallel veins striking N. 45°W., dipping 40° S. in granite were prospected by short adits and shallow shafts. Part of Southern Mother Lode. (Franke 30:441; Tucker 19:913.)
	Diamond	Not determined	S½28	24S	29E	MD	Located 1/4 mile south of White River at 1250 ft. elevation.. A 10-in. vertical quartz vein in granite de-

GOLD, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Diamond (continued)						veloped by a 42-ft. shaft and 35 ft. of drifts. (Crawford 96:470.)
	Domingo	Not determined	Appr.	14S	28E	MD	In Redwood Canyon, Tehipite quadrangle; elevation 2550 ft. Gold, silver, and copper in garnet rock in sheared slate. (See also Black Prince and Blue Bird.) (Crawford 94:296; 96:470,611.)
	Eastern Extension Isian Peak	Not determined					Lode-gold claim in White River district. Probably in Kern County. (Crawford 94:296.)
	Eclipse No. 2	Not determined	32(?)	24S	29E	MD	Located $2\frac{1}{2}$ mi. southwest of White River, in the White River quadrangle; elevation 1200 to 1750 ft. Four patented claims and millsite on two parallel veins striking N. 70° E., dipping 60° N. in granite and mica schist. Developed by a 700-ft. 60° incline; a 100-ft. crosscut with 215 ft. of drifting on the 200 level, 90 ft. of drifts on the 260 level, and 130 ft. of drifts on 700 level. Known to be controlled in 1916 by W. Tate Young of Corinth, Mississippi. (Crawford 94:296; 96:470; Franke 30:441; Laizure 23:524; Tucker 19:913-14.)
	Ely (Oliver Twist)	Not determined	27	24S	29E	MD	Located 1 mi. northeast of White River at 1260-ft. elevation. A 4- to 10-in. vein developed by a 110-ft. shaft. (Crawford 94:296; 96:471.)

GOLD, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Enterprise	Not determined					Located on Slate Mountain, 5 mi. southwest of White River at an elevation of 1380 ft. A 6-in. quartz vein dipping 80° NW. in mica schist; developed by a 50-ft. shaft and a 100-ft. tunnel. Probably in Kern County. (Crawford 96:470.)
	Eschscholtzia	Not determined	28(?)	15S	27E	MD	On Bear Mountain 5 mi. east of Auckland in the Dunlap quadrangle; elevation 2600 ft. A 10-in. vein dipping 45° W. in granite is developed by two short adits. (Crawford 94:296; 96:470.)
26	Florence G.	Not determined	30,31	21S	30E	MD	Located on northeast slope of Cow Mountain, 14 mi. east of Porterville in the Kaweah quadrangle; elevation 3300 ft. Series of parallel quartz veins with maximum width of 12 in. strike N 45° S. in granite. The ore, milled in an arrastre, contained free gold and pyrite. Developed by a 140-ft. adit, and a 150-ft. adit. (Franke 30:441; Tucker 19:914.)
	Florence and Bertha	Dan Rickards, White River (1930)					Two claims about 3 mi. southwest of White River. Developed by a 62-ft. shaft. Probably in Kern County. (Franke 30:440.)
	General Grant						See Bob Allen (Crawford 96:470.)
	Golden Treasure	Not determined					In Chileno Gulch, White River district. A 1-ft. vein dipping 20° SE. in granite is developed by two open cuts. Probably in Kern County. (Crawford 94:296.)

GOLD, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Good Enough	Not determined	Appr.	24S	29E	MD	North bank of the White River. Gold claim developed by a 110-ft. shaft (Crawford 94:296).
	Gray Eagle	Not determined	Appr.	14S	28E	MD	In Redwood Canyon, 6 mi. east of Badger in the Tehipite quadrangle elevation 2800 ft. A $4\frac{1}{2}$-ft. zone of epidote-garnet rock in sheared slate contains gold, argentiferous galena, and chalcopyrite. Developed by a 60-ft. shaft and a 150-ft. tunnel. (See also Black Prince and Blue Bird.) (Crawford 94:296; 96:470,611.)
	Guthrie (Rogers)	H.W. Guthrie, White River (1930)	13,24	24S	29E	MD	A group of claims and leases in the White River district (Franke 30:440-441; Laizure 23:524-527; Tucker 19: 912-915).
	Hard Tack	Not determined	Appr.	24S	29E	MD	Gold claim in the White River district. A 6-inch vein developed by a 30-ft. shaft. (Crawford 94:296; 96:470.)
	Hard Times	Not determined					Located in Chileno Gulch, White River district. A 3- to 6-in. vein dipping 30° S. is developed by a 70-ft. adit and open cut. Probably in Kern County. (Crawford 94:296; 96:470.)
	Harvest Home	Not determined	Appr.	24S	29E	MD	White River district. A 6- to 18- inch vein developed by a 40-ft. tunnel and a 40- and 60-ft. shaft. (Crawford 94:296; 96:470.)
	Hidden Treasure	Not determined	Appr.	24S	29E	MD	White River district. Gold claim on a quartz vein 1 to 6 in. wide dipping 30° SE. (Crawford 94:297.)

GOLD, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Homer Ranch						See under Tungsten. Some gold recovered.
	Homestake	Not determined	Appr.	25S	29E	MD	Located 2 miles southwest of White River; elevation 1200 ft. A 3- to 12- in. vein dipping 80°. Developed by a 125-ft. and a 300-ft. tunnel connected by a 46-ft. raise. Equipped with a five-stamp mill in 1894. (Crawford 94:297; 96:570; Franke 30:441; Laizure 23:527; Tucker 19:914.)
	Isian Peak	Not determined	Appr.	25S	29E	MD	Near Grizzly Gulch,White Horse district. A 6- to 12-in. vein developed by a 25-ft. shaft. Probably in Kern County. (Crawford 94:297; 96:470.)
27	Josephine	Not determined	31,32	24S	29E	MD	Nine patented claims near White River. Pyrite and galena with free gold in parallel veins striking N. 70° E., dipping 55° N. in mica schist. Development consisted of a 300-ft. 55° incline with levels at 100, 200, and 300 ft., with 400 ft. of drifts on the 100-level, 200 ft. of drifts on the 200-level, and 76 ft. of drifts on the 300-level. The average width of vein was 4 feet. (Franke 30:441; Laizure 23:527; Tucker 19:914.)
	Keys	Not determined	28	24S	29E	MD	Located 1/4 mi. southeast of White River at 1200 ft. elevation. Claims developed by 100-ft., 60-ft., and 25-ft. shafts. (Crawford 94:297; 96:470.)

GOLD, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
28	Last Chance (Redfield)	Not determined	29	24S	29E	MD	Located 2 mi. west of White River on the east bank at an elevation of 1100 ft. A 4-ft. vein, strike east, dip 80° N. in granite. Free gold with pyrite. Developed by a 265-ft. vertical shaft with levels at 100, 200, and 265 ft. Last operated by Redfield Mining Company of San Francisco in 1916. (Crawford 94:297; 96:470; Franke 30:442; Laizure 23:527; Tucker 19:915.)
	Lucky Cuss	Not determined	Appr.	24S	29E	MD	In White River district. A 3-ft. vein developed by a 100-ft. adit. (Crawford 94:297; 96:470.)
	Mammoth	Not determined	32(?)	24S	29E	MD	Located 1½ mi. southwest of White River at 1200 ft. elevation. A 3- to 8-in. vein in granite developed by a 350-ft. tunnel and 90-ft. shaft. (Crawford 96:470.)
	Mammoth	Not determined					Middle Fork of Tule River at 6300 ft. elevation. A 4-ft. vein developed by a 30-ft. tunnel. (Crawford 94:297; 96:470.)
	Minnie Ellen	Not determined	9	23S	28E	MD	Located 8 mi. southeast of Porterville in the White River quadrangle. A 5-ft. vertical vein striking northwest in granite. Developed by a 123-ft. shaft. (Franke 30:442; Laizure 23:527; Tucker 19:915.)
	Monarch	Not determined					Middle Fork Tule River at 6300 ft. elevation; adjoins the Mammoth (Crawford 96:471.)

GOLD, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Old Soldier	Not determined	Appr.	15S	26E	MD	In Drum Valley, Dunlap quadrangle. Gold prospect also garnet, topazolite, epidote, and tourmaline. (Crawford 94:297.)
	Oliver Twist						See Ely (Crawford 96:471).
	Otter	Not determined	33(?)	24S	29E	MD	Located in Coarse Gold Gulch, $1\frac{1}{4}$ mi. south of White River; elevation 1420 ft. Claim developed by 100-ft. and 60-ft. shafts. (Crawford 94:297; 96:471.)
	Page	Not determined	17	18S	26E	MD	Located 7 mi. northeast of Visalia at Venice Hills, Exeter quadrangle. Siliceous vein 2 ft. wide dipping 80° southeast is developed by two prospect shafts. Reported to contain chalcopyrite and gold. (See under Copper.) (Crawford 94:297; 96:64,471.)
	Pincher and Bulger	Not determined					On Dry Creek, Woodlake quadrangle (?). A 3-ft. vein developed by a 70-ft. inclined shaft and a 150-ft. tunnel. (Crawford 94:297; 96:471.)
	Redfield						See Last Chance (Crawford 94:297; 96:471; Tucker 19: 914-915).
29	Redwood Canyon	S.M. Mingus and E.A. Webb, Coalinga (1930)	35	14S	28E	MD	East of Badger 12 mi., in Redwood Canyon, Dunlap quadrangle. Fqur lode, four placer claims. Two parallel veins strike northwest on granite-schist and limestone-schist contacts. Shallow development. (Franke 30:441.)

GOLD, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Richelieu	Not determined	34(?)	24S	29E	MD	Located $1\frac{1}{2}$ mi. southeast of White River at an elevation of 2250 ft. A near-vertical 2-ft. vein in granite is developed by a 190-ft. shaft with a 165-ft. drift to the east and 78-ft. drift west; also a 155-ft. tunnel. (Crawford 94:297; 96:471.)
	Rogers						See Guthrie (Franke 30:440).
	Royal	Not determined	Appr.	25S	27E	MD	Slate Mountain 5 mi. southwest of White River; elevation 1400 ft. An 8-in. vein dipping 70° N. in mica schist is developed by a 90-ft. shaft. Probably in Kern County. (Crawford 96:471.)
	Sandstone	Not determined					On Blue Mountain, 4 mi. southeast of White River. A 4-ft. shear zone striking N. 75° E., dipping 75° N. in granite. Developed by three shafts 25 to 50 ft. deep. Probably in Kern County. (Tucker 19:915.)
	Sarah Tucker	Not determined	Appr.	24S	29E	MD	White River district. An 8-in. to 2-ft. vein developed by a short adit. (Crawford 94:297; 96:471.)
	Simmons	Not determined	27(?)	24S	29E	MD	On Bald Mountain 2 mi. southeast of White River at 2200-ft. elevation. A 4- to 6-in. vein dipping 20° N. in granite. Developed by a 50-ft. shaft with a 50-ft. drift and 20-ft. winze. (Crawford 94:298.)

GOLD, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
30	Southern Mother Lode	A.P.O. Crabtree, Porterville (1930)	30,31	21S	30E	MD	Located on Cow Mountain 16 mi. east of Porterville, Kaweah quadrangle. Three cliams including Creeks. (Franke 30:441; Laizure 23;527; Tucker 19:913.)
	Stancil						See Stencil (Crawford 93:298).
	Stencil (Stancil)		27(?)	24S	29E	MD	Bald Mountain $1\frac{1}{2}$ mi. west of White River at 1150 ft. elevation. Gold associated with sulfides in an 8-in. vein striking east, dipping 80° N. in granite. Developed by a 300-ft. drift, adit, and open cuts. Ore milled in arrastra. (Crawford 94:298; 96:471; Franke 30:442; Laizure 23:527; Tucker 19:915.)
	Sunset	Not determined	Appr.	24S	29E	MD	Located 3 mi. southwest of White River. A 7- to 18-in. vein striking N. 70° E., dipping 55° N., in slate. Developed by a 175-ft. adit and shafts. (Crawford 94:298; 96:471; Franke 30:442; Laizure 23:527; Tucker 19:915.)
	Sylvanite	Harvey Clark, Isabella, (1930)	Appr.	22S	35E	MD	Located in the Kernville quadrangle 3 mi. south of Bald Mountain below Rattlesnake Creek, a tributary of the Kern River. Two undeveloped claims. (Franke 30:441.)
	Vulture	Not determined	Appr.	24S	29E	MD	White River district. A 6-inch to 4-ft. vein with free gold and sulfides. Developed by 340-ft. and 80-ft. shafts. (Crawford 94:298; 96:471.)

GOLD, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Way-up	Not determined	Appr.	14S	28E	MD	Ten Mile Creek in the Finger Rock district. Tehipite quadrangle. Placer claim, ground-sluicing operation. (Crawford 94:298; 96:471.)
	W. Hart	Not determined	Appr.	14S	28E	MD	Redwood Canyon district. An extension of the Gray Eagle. (Crawford 94:298.)

MANGANESE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
31	Barbour	Ben K. Stroud, Springville (1950)	33	19S	29E	MD	Located one mi. west of Milo, 65 ft. south of road, 0.6 mi. east of Flying T Ranch house in Kaweah quadrangle. Impure pyrolusite in a 1½-ft. quartz vein in granite. Gangue minerals are glassy quartz, hematite, and limonite. The nearest shipping point is Springville, 7 mi. to the south. Developed by a pit 10 ft. in diameter and 5 ft. deep. (Bradley 18:91; Jenkins 43:64,68,91,93,206; Trask 50:341-342; Tucker 19:940-941.)
32	Cole	R.D. Cole, Lindsay (1950)	32	19S	27E	MD	Located 2 mi. northeast of Lindsay at an elevation of 680 ft. A siliceous zone 25 ft. wide and 100 ft. long between jasper and slate is mineralized with manganiferous iron ore averaging about 18 percent managanese. The slate strikes N. 20° W. and dips 75° SW. Developed by a 30-ft. shaft and an open cut exposing about 500 tons of mixed ore. (Bradley 18:91; Jenkins 43:64,68, 91,93,206; Trask 50:342; Tucker 19:941.)
33	Dry Creek	Not determined	23	15S	27E	MD	Dunlap quadrangle. Manganese is found in places for 15 mi. along Dry Creek near Badger. (Franke 30:454; Jenkins 43:64,68,91,93,206; Trask 50:342.)
	Gill Ranch	Z.E. Page (1942-43)	Appr.	20S	28E	MD	Located 10 mi. southeast of Lindsay in the Kaweah quadrangle. Mixed rhodonite and pyrolusite contain 14.9 percent manganese, 2.2 percent iron, and 69.78 percent silica. Moderate production. (Jenkins 43:64,68,91,93, 206; Trask 50:342.)
	O'Kelley	L.W. O'Kelley (1942)	Appr.	21S	29E	MD	Cronks Ranch, 13 mi. east of Porterville in the Kaweah quadrangle. Manganese oxide staining metamorphic rocks. Grade probably less than 10 percent. (Jenkins 43:64,68, 91,93,206; Trask 50:342.)

MOLYBDENUM

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
34	Griders	Not determined	10	21S	31E	MD	Located 2 mi. south of Camp Nelson in the Kaweah quadrangle. Three deposits reported. Believed to have produced in 1905. (Mineral Industry, vol. XIV:450.)
35	Kaweah Molybdenum	Kaweah Molybdenum Mining Co., 619 Crocker Bldg., San Francisco (1930)	35,36 2	15S 16S	31E 31E	MD MD	In Sequoia National Park, near Tamarack Lake in Tehipite quadrangle. Mineral rights disputed. Molybdenite with some wolframite and scheelite disseminated in granite over an area 500 by 2000 ft. A large tonnage of 5 percent MoS_2 ore reported. Developed by open cuts and a 25-ft. shaft. (Eakle 14:27; Franke 30:458; Laizure 23:47; Symons 35:46; Waring 17.)
	Kern-Sierra						Contact zone containing molybdenite and copper minerals in addition to scheelite. (See under Tungsten.) (Krauskopf 53:82.) Kernville quadrangle.
36	Wingrove	Not determined	31	23S	31E	MD	Located 1/2 mi. from California Hot Springs at an elevation of about 3300 ft. in the Tobias Peak quadrangle. Molybdenite occurs disseminated in a large vein of milky quartz. No development. (Horton 16:60,62-63.)
	Unknown	Not determined	Appr.	17S	28E	MD	Molybdenite prospect near Three Rivers (Eakle 14:27; Horton 16:60).
	Unknown	Not determined	Appr.	23S	29E	MD	White River quadrangle. Two molybdenite prospects near highway, 15 mi. east of Ducor on road to California Hot Springs. (Franke 30:458.)

NICKEL

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Deer Creek chrysoprase						Garnierite (hydrous nickel, magnesium silicate) occurs with chrysoprase in altered serpentine. See herein under Gems.
37	Deer Creek nickeliferous magnesite	Claude Slaughter, Success (1956)	21,22 28	22S	28E	MD	Nickeliferous magnesite in altered serpentine. Herein. (See also under Magnesite.)
	Lindsay chrysoprase						Garnierite associated with chrysoprase in altered serpentine. (See also under Gems.)
38	Venice Hill nickel	Uota Brothers Ranch, Box 247, Ivanhoe, Wilmot Bauman, Woodlake, Sam Newman, Visalia, Harry Fisher, Visalia; leased to Diversified Exploration Co. M.T. Williams, Lemon Cove (1955)	4,5 8,9	18S	26E	MD	Herein. (See also under Venice Hill chrysoprase in section on Gems.)

TUNGSTEN

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
39	Alice Homer	Alice Homer Ranch (1954)	34	16S	27E	MD	Located on Dry Creek, Woodlake quadrangle. Fine-grained disseminated scheelite in a small pod of tactite at the contact between granite and metamorphic rocks. No known production. (Jenkins,W.O. 43:177; Krauskopf 53:80.)
40	Anita May	Not determined	SE¼32	24S	31E	MD	Tobias Peak quadrangle, beneath power lines 100 yds. west of Sand Springs road and 3/4-mi. east of Tungstore mine. Some scheelite in a small tactite xenolith surrounded by granodiorite. Explored by two short adits during World War I. No known production. (Franke 30:465; Jenkins, O.P. 42:357; Krauskopf 53:80; Partridge 41:318.)
41	Baker Lease	H. Baker, Woodlake; leased to Kaweah Mining and Milling Co., Box 59, Lemon Cove (1954)	NW¼30	18S	28E	MD	Southeast of Lemon Cove. Herein.
42	Barrington	Mrs. Nellie Barton and A.R. Lackey; leased to A.L. Barrington (1943)	NW¼21	15S	27E	MD	Located three mi. southeast of Badger, a few hundred yards south of Highway 65 at an elevation of 2700 ft. Dunlap and Dinuba quadrangles. Scheelite-bearing tactite containing 1.0 percent WO_3 over a small area. Part of six small xenoliths in granodiorite, the largest of which is 30 ft. long and 7 ft. wide. Opened by three small cuts. Ore shipped in 1943 to the Yolohl Valley mill. (Jenkins, O.P. 42:356; Krauskopf 53:80.)

TUNGSTEN, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Barton						See Redwood Canyon (Krauskopf 53:80).
43	Baty	William Meherton; leased to S.P. Baty (1943)	34	18S	27E	MD	Rocky Hill quadrangle about 2 mi. southeast of Lind Cove at an elevation of 700 ft. Scheelite in tactite along a faulted contact between marble and schist, extending 60 ft. from a granite contact. Developed by a 15-ft. shaft and 40-ft. open cut. Shipped ore in 1943. (Jenkins, W.O. 43:179; Krauskopf 53:80.)
	Bear Mountain	Alloy Tungsten, P.O. Box 366, Dinuba	Appr.	15S	27E	MD	Prospect on Bear Mountain east of Aukland Ranch in the Dunlap quadrangle. Shipped 80 tons of 0.2 percent ore. (Jenkins, W.O. 43:175.)
	Big Jim						See Tulare County Tungsten (Krauskopf 53:80).
44	Big Mack	C.D. McCutcheon	SW¼7	21S	30E	MD	Kaweah quadrangle about 3 mi. southeast of Springville near Forest Service road, 3 mi. off sufraced road. Scheelite in tactite exposed in an area 20 ft. by 120 ft. surrounded by alluvium. No known production. (Krauskopf 53:80.)
45	Bill Waley Indian Allotment (JHB, Tom Cat)	Indian land; leased to Wheeler Mining Co., A.H. Heineman, 209 East Yosemite, Madera (1954)	SW¼2	15S	26E	MD	Herein. (Jenkins, W.O. 43:172-173, fig. 1; Krauskopf 53:16,80, fig. 11.)

TUNGSTEN, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
46	Billy Boy group	L.M. Rhoads et al.	26,27 34,35	23S	31E	MD	Tobias Peak quadrangle. Scheelite in tactite. (Jenkins, O.P. 42:357.)
47	Bob Marshall	Vernon Gill Ranch, Springville; leased to Bob Marshall, Springville (1954)	12	21S	29E	MD	Herein.
48	Blossom Peak	Alles and Beam Ranch; leased to Three Rivers Mining Corp. (1954)	SE¼ SE¼25	17S	28E	MD	Herein.
	Blue Moon	Not determined	12(?)	19S	29E	MD	Tungsten prospect. (U.S.G.S. 55).
49	Blue Ridge	M.E. White; leased to Tungstore Mines Inc. (1944)	NW¼30	23S	30E	MD	White River quadrangle, 2 mi. by dirt road from highway, at an elevation of 2000 ft. Layer of tactite 6 to 12 ft. wide and 80 ft. or more long; strikes N. 50° W., dips 60° SW. Contains 0.5 to 1.0 percent WO_3. Bordered by mica schist on southwest and granodiorite on northeast. Workings consist of three pits 12 ft. deep about 40 ft. apart. No known production. (Krauskopf 53:80.)
50	Brush Creek	S.T. Halsted, S.D. Crotsenberg, and R.D. Lewis, Kernville	NW¼34	22S	33E	MD	In Kernville quadrangle 3 mi. by trail from highway, at an elevation of 6500 ft. Tactite containing 0.5 percent WO_3 exposed in area 6 by 30 ft. on contact between marble and granodiorite at edge of pendant. Developed by open cuts. Some production. (Jenkins, O.P. 42:357; Krauskopf 53:80.)

TUNGSTEN, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Buckeye						See Eagle.
	Bull Point						See Tyler Creek (Krauskopf 53:80).
	Calvert	Not determined	15?	22S	30E	MD	Tungsten prospect (U.S.G.S. 55).
51	Carter	Mrs. Carter, Three Rivers (1953)	35	17S	28E	MD	Kaweah quadrangle, 1 mi. southwest of Three Rivers. A few feet of tactite at granite contact; poorly exposed. No production. (Jenkins, W.O. 43:177; Krauskopf 53:80.)
52	Carver	Not determined	E½22	22S	32E	MD	Kaweah quadrangle, on Dry Creek 1 mi. northwest of its junction with Kern River at an elevation of 4400 ft. Reached from Johnsondale via 4 mi. of dirt road and 1 mi. trail. Some scheelite in a tactite xenolith 4 ft. wide exposed for a length of 50 ft. and a depth of 15 ft; bordered by granodiorite. Ore mined by open cut. (Krauskopf 53:80.)
	Cedar Creek	Not determined	12(?)	16S	27E	MD	Tungsten prospect (U.S.G.S. 55).
53	Christmas	Fred Bower, Box 7, Inyokern	25,26	23S	35E	MD	Kernville quadrangle near Rockhouse Meadow. Reached via Nine Mile Canyon from Inyo County to Chimney Meadow and a 10-mi. jeep road west. Tungsten prospect with a small production. Some ore custom-milled in Kern County. Mill reported constructed in Chimney Meadow in sec. 8, T. 24 S., R. 37 E.

TUNGSTEN, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
54	Consolidated Tungsten (Drum Valley, Harrell Hill, Parlier Prospecting Association)	Consolidated Tungsten Mining and Milling Co., Mr. Claude Rouch, 14500 East Mountain View, Kingsburg	N½11	15S	26E	MD	Important source of tungsten ore. (Jenkins, O.P. 42: 356; Jenkins, W.O. 43:173-174; Krauskopf 53:14-16,80, figs. 27-31; Tucker and Sampson 41:566; herein.)
	Couger (Mecray, Hill Top)	Mr. Mecray, Bakersfield; lease to Hill Top Mining Company, Mr. Chester Henry, Lemon Cove, Mr. Wilder et al., Cobble Lodge, Three Rivers (1954)					Shipped about 100 tons of highgrade ore. Location of mine undetermined. Possibly Hill Top. (U.S.G.S. 55.)
55	Credow Mountain	W.O. Dennis Ranch; leased to Mr. Schrader and Mr. Nolan, c/o Paul Morris Ranch, R.F.D. Fountain Springs (1954)	S½SW¼ 17	23S	29E	MD	Southeast end of Credow Mountain in White River quadrangle. (Herein).
56	Crystal Queen (Daley)	Daley Ranch; leased to T.A. Hazelton, P.O. Box 136, Lemon Cove (1954)	34	18S	29E	MD	Located in Grouse Valley. Reached from South Fork road via Three Rivers. Mill under construction 1954.

TUNGSTEN, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
57	Cutler	A.R. Cutler; leased to E. Thomas and P. Cortner (1942-43)	NE$\frac{1}{4}$33	15S	27E	MD	Located on the south side of Bear Mountain, 5 mi. east of Aukland Ranch at 2700 ft. elevation, Dunlap and Dinuba quadrangles. Scheelite in tactite mass 12 ft. wide and 70 ft. long, between granodiorite and gabbro. No production. (Krauskopf 53:81.)
	Daley						See Crystal Queen.
	Davis	Not determined	10(?)	18S	27E	MD	Tungsten prospect near Lemon Cove (U.S.G.S. 55).
58	Davis Ranch	Tom Davis Ranch	N$\frac{1}{2}$29	16S	28E	MD	Tehipite quadrangle. Adjoins Homer Ranch on south. Tactite estimated to contain 0.5 percent WO_3 poorly exposed for a length of 200 ft. and a width of 10 ft. along contact between marble and quartz diorite. No exploration. Owner prefers not to develop. (Jenkins, W.O. 43:177; Krauskopf 53:81.)
	Drum Valley						See Consolidated Tungsten (Krauskopf 53:81).
59	Eagle (Buckeye)	Walter Volt and D. Shoemaker (1955-56)	SE$\frac{1}{4}$4	18S	29E	MD	Near Cinnamon Creek on the South Fork Kaweah River at an elevation of 3000 ft. Tactite containing 1.0 percent of WO_3 exposed in cuts on trenches in poorly exposed, partly metamorphosed limestone bed. Producing in 1955. Ore was milled by Kaweah Mining and Milling Co. Production small. Idle in 1956. (Jenkins, W.O. 43:177; Krauskopf 53:81.)

TUNGSTEN, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
60	Eshom Creek	C.E. Hill	NE$\frac{1}{4}$28	15S	28E	MD	Located at southeast end of Eshom Valley, 1/2 mi. from road at an elevation of 3300 ft; Tehipite quadrangle. Tactite layer 8 ft. thick bordered by granodiorite is exposed for a length of 20 ft. by a trench. No outcrops. Small part of the tactite contains 0.5 to 1.0 percent WO_3. No production. (Krauskopf 53:81.)
	Eshom Valley						See Kaweah River mine (Krauskopf 53:81).
	Gill Ranch						See Herbert and Crabb (Jenkins, O.P. 42:357; Tucker and Sampson 41:588).
	Goodhope						See Pioneer.
61	Great Western	Emery Bales, Inyokern; leased to Wilbur H. Stark, Box 87, Ridgecrest (1954)	13	24S	36E	MD	Located at north end of Lamont Meadow in the Kernville quadrangle; elevation about 6200 ft. Road under construction (1955) to join Nine Mile Canyon road at Chimney Meadow. Reported 25-ft. tactite zone in limestone, traceable 800 ft. Mill proposed. Production small.
62	Grey Fox (Three Rivers)	H.E. and R.B. Root; leased to W.F. Clinesmith and R.B. Records (1943) Gordon Mehrten (1955-56)	NE$\frac{1}{4}$9	18S	29E	MD	Reached via South Fork Kaweah from Three Rivers; elevation 2200 ft. Scheelite in tactite along vertical contact between marble and granodiorite. Prospected by three adits to a depth of 125 ft. Zone 3 to 4 ft. wide contains 0.5 to 1.0 percent WO_3. Shipped ore during 1943. Active during 1955-56. Grade of ore 0.5 to 1.5 percent WO_3. (Jenkins, W.O. 43:178; Krauskopf 53:81.)

TUNGSTEN, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Harrell Hill						See Consolidated Tungsten (Krauskopf 53:81).
63	Herbert and Crabb (Gill Ranch)	Vernon Gill, Springville	SW¼12 NW¼13	21S	29E	MD	Located two miles south of Springville (Jenkins, O.P. 42:357; Tucker and Sampson 41:588; herein).
	Hill Brothers						See Kaweah River mine (Krauskopf 53:81).
	Hill Top	Not determined	23(?)	22S	23E	MD	Tungsten prospect, possibly Couger, which see (U.S.G.S. 55).
64	Hinds Ranch	Fred Gill; leased to Claude Rouch, Consolidated Tungsten Mining and Milling Co., 14500 East Mountain View, Kingsburg (1955)	31	18S	28E	MD	Adjoins Baker lease; reached via 12-mi. unsurfaced road from Yokohl Valley. This property, now in litigation, was developed by 120-ft. and 50-ft. drifts. Some ore is blocked out. There is a 35-ton mill on the property.
65	Homer Ranch	T. Homer, Dry Creek Road via Woodlake; leased to Kaweah Mining and Milling Co., Box 59, Lemon Cove (1955)	17,19 20	16S	28E	MD	Located six miles south of Eshom Valley (Durrell 40; Jenkins, O.P. 42:356; Jenkins, W.O. 43:175-176, fig. 2; Krauskopf 53:81, fig. 12; herein).
66	Indian	H. Frames	35	24S	29E	MD	White River quadrangle southeast of White River. Scheelite in tactite. (Jenkins, O.P. 42:357; Krauskopf 53:81.)
	Jack Ranch						See Tungstore.

TUNGSTEN, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
67	J.A. Barrington	J.A. Barrington	16	15S	27E	MD	Located 2 mi. southwest of Badger in Dinuba quadrangle. Two small pods of tactite in granite. Maximum size 50 by 70 ft. Scheelite in joint planes, in fractures, and locally disseminated in tactite adjacent to intrusive. No known production. (Jenkins, W.O. 43:174.)
	JHB						See Bill Waley Indian allotment (Krauskopf 53:81).
	Johnson	Mr. Johnson, Success (1954)	Appr.	21S	31E	MD	Kaweah quadrangle south of Camp Nelson in Tule Indian Reservation. Reached via logging road from Tule Reservation. Active prospect during 1954. (See Johnson tungsten mill herein.)
	Jupiter						Claims on Kern-Sierra group, which see.
	Kaweah Mining and Milling						Herein.
	Kaweah Molybdenum						Tehipite quadrangle southwest of Tamarack Lake. Some wolframite and scheelite with molybdenite and pyrite disseminated in granodiorite. (See under Molybdenum, which was major interest.) (Krauskopf 53:81.)
68	Kaweah River (Eshom Valley, Hill Brothers, Marks)	Frank Hill, C.E. Hill, Robert Hill; leased to Frank B. Marks (1944)	NE½22 14,28	15S	28E	MD	Tehipite quadrangle, north of junction of Pierce Creek and North Fork Kaweah River, at an elevation of 3000 ft. Reached via 3-mi. unsurfaced road from Eshom Valley. Three small, lenticular marble layers partially altered to tactite in a pendant composed principally of quartz-biotite schist. The tactite contains 0.3 to 0.4 percent

TUNGSTEN, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Kaweah River (continued)						of WO_3. Prospected in 1944 by two short adits with a combined length of 180 ft. Some ore shipped. (Jenkins, W.O. 43:175; Krauskopf 53:81.)
	Kennedy						See Tungstore.
69	Kern River	S.T. Halsted, S.D. Crotsenberg, R.D. Lewis	NE¼35	22S	32E	MD	Kernville quadrangle at an elevation of 3800 ft., on either side Kern River 1/2 mi. by trail from highway, 3/4 mi. north of Bridge. Tactite containing 0.5 percent of WO_3 in two small xenoliths surrounded by granodiorite. No known development or production. (Krauskopf 53:82.)
	Kern-Sierra group (Jupiter, Whynot)	Chester Smith, F.N. Banta, Oliver Hopkins; leased to Fred Bowers, Inyokern (1954)	29,30 31	23S	36E	MD	Kernville quadrangle; elevation 6000 to 7000 ft.; reached via Nine Mile Canyon. Three claims. Sierra: Two bodies of tactite 25 ft. long and 300 ft. apart on contact between marble and quartz diorite. Intervening areas covered. Content of WO_3 is 0.6 to 1.5 percent for widths of 3 to 4 ft. Below south exposure at depth of 47 ft. adit 130 ft. long shows two layers 4 and 16 ft. thick but containing less WO_3. Jupiter: Tactite with scheelite-rich lenses up to a foot long, interbedded with schist, exposed in two cuts and a 100-ft. adit. A 50-ton gravity concentrator built in 1942 was worked intermittently in 1942-43. Whynot: Tactite layer 8 ft. thick containing 0.25 percent WO_3 plus considerable molybdenite and chalcopyrite, exposed in shallow cut 15 ft. square. (Krauskopf 53:82.)
	Krebs and Martin						See Tungstore mine (Krauskopf 53:82).
	Manikan	Not determined	3(?)	17S	28E	MD	Tungsten prospect (U.S.G.S. 55).

TUNGSTEN, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Marks						See Kaweah River mine (Krauskopf 53:82).
70	Martin	W.G. Martin, Earl Slocum, L.A. Martin, and R.C. Martin	27	18S	29E	MD	Kaweah quadrangle, on the east side of Grouse Mountain; elevation 4600 ft. Reached via 8 mi. of Forest Service road. Small outcrops of tactite with a little scheelite distributed for a mile along a poorly exposed contact between granodiorite and lime-silicate rocks. No development. (Krauskopf 53:82.)
	McKee	Edna McKee; leased to Kaweah Mining and Milling Co., Box 59, Lemon Cove (1954)	27(?)	17S	29E	MD	Kaweah quadrangle, 3 mi. from South Fork Highway. Scheelite at limestone-granite contact. No road; no development.
	Mecrey						See Couger.
71	Mineral King	Public Land	11	17S	31E	MD	Kaweah quadrangle, opposite the Cherokee Crest Guard Station. Scheelite in tactite along contact zone. (Jenkins, O.P. 42:356; Krauskopf 53:82.)
	National Tungsten						See Tyler Creek.
	North Fork	North Fork Mining Co., Flint and Johnson, Badger (1956)	Appr.	14S	27E	MD	Located in Tehipite quadrangle northeast of Badger. Low-grade tactite deposit containing scheelite. A 60-ton mill was in operation in 1955-56.
	Pacific Star	Not determined	15(?)	22S	33E	MD	Tungsten prospect (U.S.G.S. 55).
	Parlier Prospecting Assn.						See Consolidated Tungsten (Tucker 41:566).

TUNGSTEN, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
72	Pioneer (Goodhope)	Goodhope Mining Co., J.H. Loughend, 120 "O" Street, Fresno; leased to Levi Pettinger, Box 37, Three Rivers (1954-56)	SE¼ 27	18S	29E	MD	Herein.
	Powell						See under Copper.
73	Redwood Canyon (Barton)	Edith F. Barton; leased to M.C. Richardson and E. Homer (1943-44)	2	15S	28E	MD	Tehipite quadrangle in Redwood Canyon; elevation 5000 to 5500 ft. Accessible by unimproved road. High-grade scheelite ore in tactite, exposed in 40-ft. shaft and trenches. Ore shipped to Metals Reserve Co. in 1943-44. Ore reported to be refractory. (Jenkins, W.O. 43:178-82, fig. 3; Krauskopf 53:82.)
74	Royal Tungsten	G.W. Hicks and J.C. Brockman, Three Rivers (1954)	27	18S	29E	MD	Kaweah quadrangle, on west side of Grouse Mountain; adjoins Martin claims. Scheelite erratically distributed through tactite body 50 ft. wide and 700 ft. long, along contact between marble and granodiorite. Active in 1954. (Jenkins, O.P. 42:356; Jenkins, W.O. 43:178; Krauskopf 53:82.)
	Schrader-Nolan						Tungsten mill; see also Credow Mountain tungsten mine. Herein.
	Sequoia National Park	Within Sequoia National Park	13	16S	29E	MD	Tehipite quadrangle, several miles southwest of Park headquarters. Scheelite in tactite along highway. (Jenkins, O.P. 42:356; Krauskopf 53:82.)

TUNGSTEN, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
75	Sherman Peak	Sherman Peak Mining Co. L.G. Embree, P.O. Box 583, Kernville	23	22S	33E	MD	Mines and mill about 6 mi. east of Roads End north of Kernville. Has been a consistent source of tungsten concentrates since 1947.
	Sierra						Part of Kern-Sierra group, which see.
	Sierra Nevada	Emery Bales, Inyokern; leased to Wilbur H. Stark, Box 87, Ridgecrest (1954)	15(?)	24S	36E	MD	Kernville quadrangle, northwest of Lamont Meadows at an elevation of about 7000 ft. Scheelite prospect.
76	Stony Creek	Taylor and Cortnell (1954)	NE¼ 7	15S	29E	MD	Tehipite quadrangle on Stony Creek; reached via 3-mi. unimproved road from Highway 180. Scheelite in tactite. Estimated WO_3 content 1.5 to 2.0 percent. Developed by 12-ft. and 8-ft. prospect pits. Float; no ore found in place. Idle.
77	Sunnyside	J.D.Stockton	1,12 6	22S 22S	32E 33E	MD MD	Olancha quadrangle, on east side of Kern River, 5 mi. by trail from highway. Scheelite in several narrow layers of tactite containing 0.5 to 1.0 percent of WO_3; Along contact between granite and marble. Undeveloped. (Krauskopf 53:82.)
78	Thanksgiving	Will Gill Ranch; leased to Butcher, Doyle, and Conlee, Box 354, Exeter (1954)	NW¼ 31	19S	29E	MD	Mine and mill northwest of Milo (herein).

TUNGSTEN, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Three Rivers						See Grey Fox (Jenkins, O.P. 42:356; Krauskopf 53:82).
	Tom Cat						See Bill Waley Indian allotment (Krauskopf 53:82).
	Triangle	Joe Astringer, Inyokern (1954)	Appr.	23S	35E	MD	Kernville quadrangle. Reached via Nine Mile Canyon road from Inyo County. Production reported.
79	Tulare County Tungsten (Big Jim)	Will Gill Ranch; leased to Tulare County Tungsten, D.F. Lauricella, Box 361, Lindsay (1954)	$NE\frac{1}{4}$11	19S	28E	MD	A major source of tungsten in Tulare County; in Kaweah quadrangle. (Jenkins, O.P. 42:356; Jenkins, W.O. 43:179; Krauskopf 53:82; Trengove 56:12 pp; herein.)
80	Tule Indian Reservation	Indian land	7	22S	30E	MD	Kaweah quadrangle, in the Tule Indian Reservation. Scheelite in tactite. (Jenkins, O.P. 42:357; Krauskopf 53:82.)
81	Tungstore (Kennedy, Krebs and Martin, Jack Ranch)	Tungstore Mines Co., C.A. Rasmussen and W. A. Trout	$SE\frac{1}{4}$32	24S	31E	MD	First tungsten mine in Tulare County. Large production. (Franke 30:464; Jenkins, O.P. 42:357; Krauskopf 53:83; Partridge 41:318; herein.)
82	Tyler Creek (Bull Point, National Tungsten, Verne Tyler, Western Exploration)	Verne Tyler Ranch and Mr. Lundeene, California Hot Springs; Mrs. Rounsaville, Porterville; leased to National Tungsten Corp. 148 North Main Street Porterville (1955-56)	$N\frac{1}{2}$35	23S	30E	MD	Tobias Peak quadrangle, 2 mi. west of California Hot Springs. (Krauskopf 53:83; herein.)

TUNGSTEN, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Verne Tyler						See Tyler Creek mine (Jenkins, O.P. 42:357; Krauskopf 53:83; Partridge 41:319).
	Western Exploration						See Tyler Creek mine (Jenkins, O.P. 42:356).
83	White River Lode	H.G. Vincent, Star Route 1, Porterville; leased to H.A. Records (1943)	S½32	24S	29E	MD	White River quadrangle, near Eclipse mine, 2 mi. south of White River. Scheelite in quartz stringers at granite contact with slate and limestone; also chrysocolla. Developed by 10-ft. adit and open cuts. Active in 1943. Production not known. (Hubbard 43; Laizure 43:57; Krauskopf 53:83.)
	Whynot						Claim in Kern-Sierra group, which see.
84	Wible	Tungstore Mines Company, C.A. Rasmussen and W.A. Trout	SW¼31	24S	31E	MD	Tobias Peak quadrangle, west of the Tungstore mine; elevation 4500 ft. Three layers of tactite interbedded with schist and quartzite in pendant surrounded by granodiorite. The tactite was 5 to 20 ft. thick, 90 ft. long, and was cut off by granodiorite at a depth of a few feet. The ore was low grade and was milled at the Tungstore mill. Worked in 1938-39 by an open pit 25 to 90 ft. wide and 300 ft. long. (Jenkins, O.P. 42:357; Krauskopf 53:83.)
85	Yokohl Valley	Will Gill Ranch, Springville (1942)	11	19S	27E	MD	Rocky Hill quadrangle. Scheelite in tactite. No development. (Durrell 40; Jenkins, O.P., 42:357.)

URANIUM AND THORIUM

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
86	Bezzarides	Paul Bezzarides, P.O. Box 1303, Orosi (1955)	3	16S	25E	MD	Radioactivity noted in a group of pegmatite dikes in decomposed granite northeast of Orosi. Minerals in the pegmatite are muscovite, quartz, tourmaline, and epdiote. No uranium minerals identified; however, assays show a trace of uranium. Prospect developed by 10 bulldozer cuts to a maximum depth of 10 ft. (Atomic Energy Commission 1955.)
87	Big Four No. 1	E. Task and E.J.Hoover 2210 Norwalk, Delano (1955)	17	24S	31E	MD	South of California Hot Springs. Radioactivity confined to two sets of joints in granite. One set trends N. 30° W. and dips 72° SW; the other trends N. 68° E. and dips 80° SE. Prospect developed by a 5-ft. open cut. About 3 ft. from the prospect is a highly bleached 2-ft. shear zone striking N. 80° E., dipping 74° NW. Torbernite was identified in association with molybdenite and pyrite. (Atomic Energy Commission 1955.)
88	Chico No. 1	Fred C. Asmann, 3960 Greenwood Ave., Oakland (1955)	35	22S	32E	MD	On the Kern River. Radioactivity noted in a pegmatite dike striking N. 35° W., dipping 60° SW in biotite granite. Prospect developed by a discovery pit. No uranium minerals identified; however, assays show a trace of uranium. (Atomic Energy Commission 1955.)
89	Dead Tree	Jack Roberts and John Morrison, General Delivery, Kernville (1955)	28,29	23S	33E	MD	Located in the Salmon Creek area. A total of 27 claims located in an area of pegmatite dikes. No uranium minerals identified. (Atomic Energy Commission 1955.)
90	Divine No. 1 and No. 2	Carl L. Divine, Route 6, Box 472, Visalia (1955)	11	16S	26E	MD	About 8 mi. northeast of Orosi; 10-ft. discovery pit on pegmatite dike in decomposed granite. No uranium minerals identified. (Atomic Energy Commission 1955.)

URANIUM AND THORIUM, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R	B & M	REMARKS
91	Former	Mrs. M.C. Morey, 1240 Benedict Canyon Drive, Beverly Hills (1955)	24	23S	32E	MD	In the Salmon Creek area. Radioactivity noted in a 1- to $1\frac{1}{2}$-ft. shear zone in granite. The zone strikes N. 52° E., dips 84° SE. Silicification, bleaching, and iron staining are prominent. No uranium minerals identified. (Atomic Energy Commission 1955.)
92	Griffith	T.W. Helsey, Route 4, Box 406, Tulare (1955)	14	17S	29E	MD	About 5 mi. northeast of Three Rivers. Radioactivity concentrated along weak shear zones in granite. Zones trend north, dip 75° W. No uranium minerals identified. Prospect developed by a 6-ft. discovery pit. (Atomic Energy Commission 1955.)
93	Jay Bird No. 1	John Gibson, 28 March Street, Bakersfield (1955)	25	23S	32E	MD	In Salmon Creek area. Two 5-ft. test pits expose a 2- to 4-ft. quartz vein which trends N. 80° E. and dips 88° S. The walls are slickensided, bleached, silicified, and iron stained. Minerals identified in the vein are torbernite, pyrite, and iron oxides. (Atomic Energy Commission 1955.)
	Lamont Meadows	Emery Bales, Inyokern (1956)	Appr.	24S	37E	MD	In Lamont Meadows; reached via Nine Mile Canyon from Inyo County. An unidentified uranium-thorium mineral with magnetite and ilmenite in granite pegmatite.
	Long Valley	Emery Bales, Inyokern (1956)	Appr.	24S	36E	MD	Near Long Balley.Granite pegmatite containing uraninite, euxenite, monazite, and a trace of autunite, associated with ilmenite, magnetite, and molybdenite.

URANIUM AND THORIUM, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
94	Sequoia Ranch	Dock Walker, P.O. Box 125, Springville (1955)	2	21S	29E	MD	Near Springville. Euxenite identified in pegmatite dike 6 to 10 ft. wide, striking N. 70° E. in granite. Prospect developed by a 6-ft. open cut. (Atomic Energy Commission 1955.)
95	Tomlee	Joseph Thomas, General Delivery, California Hot Springs (1955)	23	23S	28E	MD	About 5 mi. northeast of Ducor. Radioactivity noted in an east-west shear zone 1 to $1\frac{1}{2}$ ft. wide. Dip is south. Originally a gold prospect developed by a 75-ft. shaft; now filled to within 12 ft. of surface. Uranium-bearing mineral not identified. (Atomic Energy Commission 1955.)
96	Visalia Land and Investment Co.	A. Weaver, P.O. Box 1015, Avenal (1955)	12	17S	29E	MD	Northeast of Three Rivers. A trace of autunite was found along heavily iron-stained shear zone in granite. The zone strikes northeast and dips 80° N. Maximum width 1 ft. traceable for 100 ft. Prospect developed by an 8- by 8-ft. shaft 30 ft. deep. (Atomic Energy Comission 1955.)

ZINC-LEAD-SILVER

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Arsenic and Soda Springs	Harry Ford, Virgil Prichard, and Leslie Mumbleau, Camp Wishon (1930)	Appr.	20S	31E	MD	Kaweah quadrangle, Camp Wishon district. Lead-zinc claims. (Franke 30:471.)
	Black Jack						See King Solomon (Franke 30:471).
97	Cedar Hill	R.H. Frantzich, 800 "G" Street, Fresno; leased to Ben Bell, 124 Oakdale Drive, Bakersfield (1952)	29	19S	31E	MD	Kaweah quadrangle, on the North Fork of Middle Fork Tule River, about 4 mi. north of Camp Wishon. Complex ore containing zinc, lead, and copper. Developed by a 10-ft. shaft and 50-ft. tunnel. Shipped lot to smelter in 1943. (Eric 48:352; Franke 30: 437,467.)
98	Chihuahua	Not determined	13	17S	31E	MD	Kaweah quadrangle 2 mi. east of Mineral King on ridge between Lake and Rock Gorge Canyons at an elevation of 10,500 ft. A 12-inch quartz vein striking northwest, dipping 75° S. on contact between limestone and slate is mineralized with galena and pyrite. Developed by a 150 ft. crosscut adit prior to 1916. (Franke 30:471; Tucker 19:949.)
99	Comanche	Not determined	22	17S	31E	MD	Located $1\frac{1}{2}$ miles southwest of Mineral King on top of ridge between Eagle Lake and Mosquito Lake Canyons, at an elevation of 9600 ft. A 12-in. vein striking north, dipping 80° W. in slate is mineralized with sphalerite in an epidote gangue. Developed by a 50-ft. shaft prior to 1916. Later incorporated with Sequoia. (Franke 30:469; Tucker 19:949.)

ZINC-LEAD-SILVER, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Crystal prospect	Not determined	Appr.	17S	31E	MD	Located 2 mi. northeast of Mineral King in Lake Canyon, at an elevation of 10,000 ft. A 6- to 12-in. vein striking north, dipping 75° W. on limestone-slate contact is mineralized with galena and sphalerite. Developed by a 20-ft. shaft prior to 1916. (Franke 30:471; Tucker 19:949.)
	Dolly Varden	Not determined	Appr.	17S	31E	MD	Located near the Comanche at an elevation of 10,000 ft. An 8- to 12-in. quartz vein striking N. 60° E., dipping 65° N. in granite contains argentiferous galena and sphalerite. Vein is in a fault zone. Developed by a 25-ft. incline prior to 1916. See also Sequoia. (Franke 30:469; Tucker 19:949-950.)
	Elder Berry	Bill Elster, Camp Wishon (1930)	Appr.	20S	31E	MD	Zinc-lead claims in the Camp Wishon district (Franke 30:471.)
	Elster	Bill Elster, Camp Wishon (1930)	4(?)	20S	31E	MD	Kaweah quadrangle, Camp Wishon district. Veinlets of sphalerite and galena in contorted slate and chlorite schist. Gangue minerals are quartz, epidote, garnet, diopside, and calcite. (May be same as King Soloman, which see.) (Franke 30:467.)
	Empire	Not determined	Appr.	17S	31E	MD	Located 1 mi. northeast of Mineral King on the south slope of Empire Mountain at 10,400 ft. elevation. Sphalerite, galena, arsenopyrite, and gold in a calcite, quartz, epidote gangue. Prospected by several long adits. First discovered in 1875. (Franke 30:467-468; Goodyear 88:645; Knopf 05; Laizure 23;538; Tucker 19:950; Turner 94:231.)

ZINC-LEAD-SILVER, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Empire North Extension	Not determined	Appr.	17S	31E	MD	Lead-zinc claim north of the Empire. Developed by a short adit and several shallow shafts. (Tucker 19:950.)
	Franklin Fair	Not determined	Appr.	17S	31E	MD	Zinc-lead-silver prospect located 1½ mi. southeast of Mineral King at the intersection of Fairwell Gap and Franklin Canyons. (Franke 30:471; Tucker 19:950.)
100	Galena Cave	R.V. Powell, Camp Wishon (1930)	29	19S	31E	MD	Lead prospect in Camp Wishon district. Reached via trail along the North Fork of the Middle Fork of Tule River from Camp Wishon. (See also Powell under Copper.) (Franke 30:467.)
	Harding	John Hardin, Camp Wishon (1930)	Appr.	19S	31E	MD	Zinc-lead prospect northeast of King Soloman claims in the Camp Wishon district. Prospected by shaft, tunnel, and open cuts. (Franke 30:471.)
	Iron Capping						See under Copper.
	King Soloman (Black Jack)	D. Elkins, 140 North Gardner Street, Hollywood, and Bill Elster, Springville (1930)	Appr.	20S	31E	MD	Located 3 mi. northeast of Camp Wishon, near Alder Creek at an elevation of 5000 ft. Two claims. Assay reported 29.61 percent zinc, 1.22 percent lead, 2.60 oz. silver and a trace of gold. Developed by a 220-ft. adit. Probably same as Elster, which see. (Franke 30:471.)
101	Lady Franklin	T.J. Crabtree, Porterville (1930)	25	17S	31E	MD	Located 1½ mi. southeast of Mineral King on slope south of Lady Franklin Canyon, at an elevation of 9800 ft. Galena, sphalerite, chalcopyrite, arsenopyrite, and stibnite occur in a 3- to 4-ft. zone of epidote-calcite rock

ZINC-LEAD-SILVER, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Lady Franklin (continued)						between schist and limestone. Developed by a 200-ft. adit, several shafts, and open cuts. About 200 tons of complex ore reported on dumps in 1916. (Franke 30:468-469; Goodyear 88:647; Tucker 19:951.)
	McGeorge	George McGeorge, Camp Wishon (1930)	Appr.	21S	31E	MD	Located 2 mi. east of Camp Wishon. Zinc-lead-silver prospect developed by open cuts and short adits. (Franke 30:467.)
	McGinnis	W.F. Cord, Porterville (1930)	Appr.	17S	31E	MD	Located 1½ mi. northeast of Mineral King on a ridge north of Monarch Canyon at an elevation of 10,600 ft. Interbedded limestone and slate in contact with granite. Epidote-bearing zone along contact is mineralized with galena and sphalerite in a zone 1 to 3 ft. wide striking N. 45° W., dipping 75° S. Developed to a maximum depth of 25 ft. by shafts, adits and open cuts. (Franke 30:469; Tucker 19:951-952.)
	Meadows	Not determined	Appr.	19S	31E	MD	Camp Wishon district. Located on a ridge north of the North Fork Alder Creek at an elevation of 5200 ft. Three claims on a 3-ft. zone mineralized with sphalerite in an epidote gangue. Zone strikes N. 40° W., dips 45° N. on contact between limestone and mica schist. Prospected by open cuts and short adits. (Tucker 19:952.)
	Monarch	Not determined	Appr.	19S	31E	MD	Camp Wishon district. Sphalerite in epidote gangue in limestone and schist; eight claims. (Tucker 19:952.)

ZINC-LEAD-SILVER, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Peach Dumplin	Not determined	Appr.	20S	31E	MD	Camp Wishon district; on ridge north of Alder Creek. Sphalerite in epidote gangue. (Tucker 19:952.)
	Powell						See under Copper.
102	Prince Albert		3	20S	31E	MD	Zinc-lead-silver prospect in the Camp Wishon district (Franke 30:467).
	Sequoia (Sequoia-Silver Lead)	C.T. Williams, Box 4, Porterville (1930)	Appr.	17S	31E	MD	Seven claims northwest of Mineral King on East Fork Kaweah River at 7500 ft. elevation. A 7- to 30-ft. mineralized zone strikes north, dips steeply in limestone between schist and granite. Trial shipments made to smelter. (Franke 30:469; Knopf 05; Laizure 23:538; Tucker 19:949-950.)
	Silver King	Not determined	Appr.	17S	31E	MD	Located 2 mi. southeast of Mineral King, in Franklin Canyon below Franklin Lakes; elevation 10,000 ft. Galena and sphalerite are in a zone striking north, dipping 75° E. along contact between siliceous limestone and slate. Developed by shallow shafts along outcrop. (Franke 30:471; Tucker 19:952-53.)
	Silver Lake Zinc	Not determined	Appr.	17S	31E	MD	Located 2 mi. southeast of Mineral King on slope north of Lower Franklin Lake; elevation 10,600 ft. Sphalerite on contact between limestone and granite; also along epidote zone 40 ft. wide. Maximum width of ore is 4 ft. Developed by prospect pits prior to 1916. (Franke 30:469-470; Tucker 19:953.)

ZINC-LEAD-SILVER, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Silver Queen	Not determined	Appr.	17S	31E	MD	Located 2 mi. southeast of Mineral King in Franklin Canyon at 10,000 ft. elevation. Sphalerite and galena in epidote gangue on contact between siliceous limestone and slate. (Tucker 19:953.)
103	Skylark	Not determined	20	19S	31E	MD	Prospect in Camp Wishon district (Franke 30:467).
104	Thunder Shower and Buckhead Zinc	Not determined	5	20S	31E	MD	On ridge north of North Fork Alder Creek at 5200 ft. elevation; 6 to 8 ft. of sphalerite on contact between irregular limestone lenses and mica schist. Developed by a 208-ft. adit. (Tucker 19:953.)
105	White Chief	Not determined	31	17S	31E	MD	Located $2\frac{1}{2}$ mi. south of Mineral King in White Chief Canyon at 10,000 ft. elevation. The original discovery at Mineral King (1873). Argentiferous galena and sphalerite in limestone near granite contact. Ore zone 6 to 8 ft. wide in outcrop. Developed by adits and open cuts. About 200 tons of ore reported on dumps. (Franke 30:470; Goodyear 88:646; Knopf 05; Tucker 19:953-954.)
106	White Horse	Not determined	11	17S	31E	MD	About $1\frac{1}{2}$ mi. north of Mineral King on slope southeast of Timber Gap at 11,400 ft. Sphalerite and galena on limestone-granite contact. Developed by several adits and shafts prior to 1916. May be in Sequoia National Park. (Franke 30:471; Tucker 19:954.)
107	Young America	Not determined	1,2	17S	31E	MD	On Cliff Creek northeast of Mineral King. Now in Sequoia National Park. Sphalerite and galena occurs on limestone-granite contact. (Franke 30:471; Tucker 19:954.)

ASBESTOS

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Frazier Valley	Not determined	Appr.	20S	29E	MD	Asbestos locality on the Tule River (Franke 30:431; Hamilton 20:257; Tucker 19:905).
	Fred Gill Ranch	Not determined					Asbestos near Exeter (Franke 30:431).
108	Hanggi Ranch	Morris Hanggi, 121 Burrel Avenue, Visalia (1955)	N½15	18S	26E	MD	Herein.
	James Ranch	Not determined					Asbestos locality north of Porterville (Franke 30:431; Hamilton 20:257; Tucker 19:905).
	McCann Ranch	Not determined					Asbestos in serpentine near White River (Franke 30:431; Hamilton 20:257; Tucker 19:905).

BARITE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Bald Mountain Barite	Not determined					High barite content reported in slate and schist near Rattlesnake Creek on upper Kern River between 8000 and 9000 ft. elevation (Franke 30:431).
	Barite King						See Paso-Baryta.
	Baumann Ranch	Glover Baumann, 754 West Inyo Street, Tulare (1930)					Barite prospect on Baumann Ranch about 15 mi. east of Exeter (Franke 30:431).
109	Camp Nelson Barite	Mr. A. Montrose, 1008 Third Street, Porterville (1955)	SW¼33	20S	31E	MD	(Kundert 54; herein.)
	Nine Mile Canyon Barite						See Paso-Baryta.
110	Paso-Baryta (Barite King, Nine Mile Canyon Barite)	Jack Richards, San Fernando, and Western Barium Corp., San Francisco (1954)	34,35, 2	23S 24S	36E 36E	MD MD	(Franke 30:431; herein.)

CLAY

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Pioneer Brick Co.	Not determined					Brick plant located on Mill Creek at Visalia. Capacity 40,000 brick per day. Inactive since before 1928. (Tucker 17:906.)
111	Sears Clay	Not determined	26,27 35	24S	28E	MD	Located 8 mi. southeast of Ducor. A bed of white clay 6 to 8 ft. thick underlain by blue clay and overlain by 8 ft. of gravel and clay. Beds strike northwest and extend for 1/2 mi. south of White River and for 2 mi. along the south bank. Clay reported suitable for tile, sewer pipe, brick; and terra cotta. (Dietrich 28:232; Franke 30:432; Hamilton 20:257; Tucker 17:905.)
112	S.P. Brick and Tile	S.P. Brick and Tile Company, 326 Parallel Avenue, Fresno (1955)	3	19S	26E	MD	Near Exeter (Boalich 20:101; Dietrich 28:232; Franke 30:432-433; Laizure 23:523; Tucker 17:906; herein).
113	Valencia Heights	C.H. Weed, Porterville (1916)	34	21S	28E	MD	Clay shale, about 6 mi. east of Porterville. Reported suitable for manufacture of certain clay products. (Boalich 20:101; Dietrich 28:232,327; Franke 30:433; Tucker 17:906.)

FELDSPAR

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
114	Britton Ranch	Noel Britton, Three Rivers (1930)	23,24 25	17S	29E	MD	Massive outcrops of feldspar reported. No development. (Franke 30:439; Tucker 19:911.)
	Carter deposit	Not determined	Appr.	17S	28E	MD	Feldspar deposit about 1/2 mi. east of Kaweah River. Pods and veinlets of white orthoclase in pegmatitic granite. Maximum width of pods 6 to 18 in. Production reported prior to 1916. (Franke 30:439; Hamilton 20:258; Tucker 19:911.)
	Goodale deposit	Not determined					Reported shipping feldspar from Lemon Cove about 1914-16 (Franke 30:439; Tucker 19:911).
115	Honora Reality	Not determined	SW$\frac{1}{4}$15	18S	27E	MD	Deposit located 1$\frac{1}{2}$ mi. from Lemon Cove. Reported clay sold to porcelain manufacturers. (Franke 30:439; Tucker 19:911.)
	Yokohl Valley	Not determined					Shipments of feldspar made by lessees and property owners from Yokohl Valley area (Tucker 19:912).

GEM MATERIALS

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	LOCATION T.	LOCATION R.	LOCATION B & M	REMARKS
116	Deer Creek Chrysoprase	Rube Shannon Ranch (1955)	20,29	22S	28E	MD	See also under Nickel (Tucker 19:911; herein).
	Idocrase						Red porphyroblasts of idocrase with wollastonite and diopside in Kaweah quarry at Terminus Beach. (See Kaweah quarry, under Limestone.) (Murdoch and Webb 48.)
117	Lindsay Chrysoprase	Not determined	SW$\frac{1}{4}$ NW$\frac{1}{4}$5 N$\frac{1}{2}$ NE$\frac{1}{4}$17	20S 20S	27E 27E	MD	At Todds Hill and Chrysoprase Hill in the Lindsay quadrangle. Veinlets of chrysoprase in silicified, lateritized serpentine were mined about 1898. Total production about 500 pounds. The largest pit is 30 ft. wide, 150 ft. long and about 6 ft. deep. (See also Nickel.) (Aubury 05:74-75.)
	Old Soldier	Not determined	Appr.	15S	26E	MD	Gold mine in Drum Valley reported to have yielded garnet, topazolite, epidote, and tourmaline (Crawford 94:297).
118	Rhodonite	Not determined	22,34	16S	27E	MD	Near Dry Creek in Dunlap quadrangle. Massive rhodonite in contact-metamorphic zone. (Murdoch and Webb 48; Sterrett 11:1063; Tucker 19:911.)
119	Stokes Mountain Chrysoprase	Not determined	9,10	16S	26E	MD	About 7 mi. north of Woodlake in the Dunlap quadrangle. Small seams of chrysoprase in silicified serpentine (?). (Tucker 19:1911.)
	Sumner Rose Quartz	Not determined					Rose quartz prospect near Kern County line about 8 mi. southeast of California Hot Springs (Sterrett 11:1062; Tucker 19:910).

GEM MATERIALS, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Tule River Chrysoprase	Not determined					(Aubury 05.)
	Venice Hill Chrysoprase						See under Nickel (Crawford 96:642; Tucker 19:911).

GRAPHITE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
120	Camp Nelson Graphite	V.K. Nash, Porterville (1930)	34	20S	31E	MD	Large, low-grade graphite deposit about 18 mi. east of Springville on road to Camp Nelson; elevation 5000 ft. (Franke 30:444).
121	Drum Valley	Not determined	4,5	15S	26E	MD	Graphite deposits reported in Drum Valley (Aubury 06:280; Crawford 96:642; Hamilton 20:258-59; Tucker 17:917).

LIMESTONE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Abramson and Bode						Mined Lindsay deposit, now called Simons, which see (Franke 30:447; Logan 47:340).
	Allen	Byron Allen (1947)	All $SE\frac{1}{4}$ except $SE\frac{1}{4}$ $SE\frac{1}{4}$ 25	17S	28E	MD	Near Blossom Peak deposit (Logan 47:336).
	Alles	Daniel Alles, Alles and Beam Ranch; leased to Three River Mining Corp. (1954)	$SE\frac{1}{4}$ $SE\frac{1}{4}$ 25	17S	28E	MD	Adjoins Blossom Peak limestone deposit. Part of area now of interest for tungsten. (See Blossom Peak deposit under Tungsten.) (Logan 47:336.)
	Alles and Connor						Operated small quarry, probably on Blossom Peak deposit, which see (Logan 47:336).
122	Blossom Peak	Ideal Cement Co., 821 Seventeenth Street, Denver 2, Colorado	$SW\frac{1}{4}$ 25	17S	28E	MD	Part of a large, north-trending lens of blue-gray to black, medium-grained, crystalline limestone astride the Three Rivers-Garfield Big Trees road half a mile southeast of Three Rivers. The mass is several hundred feet wide and more than a mile long. Some parts are siliceous and others contain granitic intrusions but most of the rock is suitable for portland cement. Logan (1947, p. 336) lists one analysis showing a $CaCO_3$ content of 92 percent and a $MgCO_3$ content of less than 1 percent. (Franke 30:445; Logan 47:335-336.)
	Boydston Bros. quarry						See Worth (Franke 30:444-445; Logan 47:336).

LIMESTONE, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Britten limestone	Noel Britten, Three Rivers (1947)	$N\frac{1}{2}$25	17S	28E	MD	Either adjoins or now is part of the Blossom Peak property held by Ideal Cement Company. (See Blossom Peak deposit.) (Tucker 19:918; Franke 30:445; Logan 47: 336-337.)
	Cortner group	Not determined		15S	28E	MD	On stockraising homestead 2 mi. southeast of Eshom Creek Camp. Undeveloped deposit of white, coarsely crystalline limestone. (Franke 30:445; Logan 47:337.)
123	Devil's Thumb	Not determined	2,3, 10,11, 14	23S	30E	MD	Located 5 mi. north and slightly west of California Hot Springs just south of the Tule River Indian Reservation. Accessible by dirt road via Deer and Gordon Creeks. Undeveloped. (Franke 30:445; Logan 47:337.)
	Fort Hill	Not determined					Three Rivers district, probably adjacent to the Blossom Peak deposit. A single analysis listed by Franke (1930) showed over 99 percent $CaCO_3$.
	Gill						See Holdridge (Franke 30:445; Logan 47:337; Tucker 19: 918).
	Gill Ranches deposit						See Holdridge (Logan 47:337; Tucker 19:918).
124	Holdridge	Ideal Cement Co., 821 Seventeenth Street, Denver 2, Colorado	$N\frac{1}{2}$ and $SE\frac{1}{4}$13	21S	28E	MD	Consists of two lenses of medium- to coarse-grained light-gray and variegated limestone more or less enveloped in hornblende amphibolite. The axial plane of the principal lens strikes N. 60° E. and dips steeply southwest; it is several hundred feet wide and roughly a quarter of a mile long. The smaller lens, lying en

LIMESTONE, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Holdridge (continued)						echelon slightly to the northwest, is less than half the size of the larger lens. Larger lens is developed by several crosscut adits and a small quarry 45 x 70 ft. in plan. Tallest quarry face is about 40 ft. high. The following analyses are probably representative of the clean rock of the deposit. Some dark and some light granitic dikes cut the mass and have introduced silicate minerals in some places. The clean spot samples were collected by O.E. Bowen and C. H. Gray in 1954; analyses by Abbott A. Hanks, Inc., of San Francisco:

Oxide	Sample 1	Sample 2	Sample 3
SiO_2	0.36	0.52	0.20
Fe_2O_3	0.17	0.11	0.05
Al_2O_3	0.53	0.51	0.29
CaO	53.65	54.35	54.52
MgO	1.10	0.55	0.45
P_2O_5	0.12	0.06	0.05
$\left\{ \begin{array}{l} CO_2 \text{ (calc.)} \\ +H_2O \end{array} \right.$	44.1	43.9	44.4

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
							(Franke 30:445; Logan 47:337-338; Tucker 19:918.)
	Jacobs quarry						See Lemon Cove (Goodyear 88:644).
	James marble	Not determined					About 8 mi. southeast of Porterville on road to Tule River Indian Reservation. "A deposit of dark gray marble, claimed to be suitable for building purposes". (Aubury 06:108; Logan 47:338; Tucker 19:919.)

LIMESTONE, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Johansen	Grover Johansen, Rt. 1, Box 98, Corcoran (1947)					Probably adjacent to the Devils Thumb deposit north of California Hot Springs (Logan 47:338).
	Kaweah Lime Products Company						See Lemon Cove (Franke 30:445; Laizure 23:529; Logan 47:339).
	Kaweah Quarries						See Lemon Cove (Franke 30:445; Logan 47:339).
	Kernville quadrangle deposits	Not determined	24,25	22S	32E	MD	Crystalline calcite marble in Kernville series of metamorphic rocks in northwestern portion of Kernville quadrangle. In mountainous country, altitudes of 4000 to 6000 ft. Undeveloped. (Logan 47:341; Miller 40:349, pl. 2.)
	Lavelle	Ruth Gratto, Jesse Lavelle, Betty White (1947)	$N\frac{1}{2}SW\frac{1}{4}$ 30	17S	29E	MD	Located 2 mi. east of Three Rivers. Source of much of limestone burned in old kiln near South Fork of Kaweah River. (Franke 30:445; Logan 47:338-339.)
125	Lemon Cove (Kaweah Lime Products Co., Kaweah Quarries)	Morgan Keaton, Route 1, Box 658, Fairoaks (1947)	$NE\frac{1}{4}$35 $NW\frac{1}{4}$36	17S	27E	MD	Several thin lenticular masses of limestone interbedded with mica schist and siliceous limestone from a belt crossing the lower slopes of Limestone Hill in a northwesterly direction. The dip of the schistosity in the metasediments is 60-80° southwest. The limestone is coarsely crystalline and ranges from pure white to nearly black. None of the masses exceed 75 ft. in width and most do not exceed 50 ft. Four large quarries, each greater than 40 x 135 ft. in plan, and several smaller pits expose the limestone in faces as much as 100 ft.

LIMESTONE, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Lemon Cove (continued)						high. Most of the readily accessible rock has already been quarried although additional reserves exist underground. This property has been the largest producer in the county but has been idle since 1932. During the peak year, 1924, production reached 24,000 tons and 30 men were employed. Rock was utilized for agricultural limestone, asphalt filler, concrete pipe aggregate, and for sugar refining. (Aubury 06:94; Franke 30:445; Laizure 23:529; Tucker 19:918-919.)
	Lindsay						See Simons.
126	Moorehouse Creek	Riverside Cement Co., 621 South Hope Street, Los Angeles	29,30 31,32	20S	31E	MD	Part of an immense limestone belt 2500 ft. or more wide and several miles long about 14 mi. east of Springville astride the Camp Nelson road. Property consists of 998 acres of patented land. Limestone is medium- to coarse-grained and blue-gray to white crystalline; some black, slaty material and some fine-grained travertine. Logan (1947, pp. 339-340) lists analyses and some additional data. (Tucker 19:919; Franke 30:445-446; Logan 47:339-340.)
	Oat Canyon						See Simons, also Gill Ranches (Laizure 23:529; Logan 47:340).

LIMESTONE, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
127	Simons (Abramson and Bode, Lindsay, Oat Canyon, Valley Lime Co.)	E.J.Simons, c/o General Machinery Co., Spokane, Washington (1947)	SE¼6	20S	28E	MD	Medium to fine crystalline, blue-gray to black dolomitic limestone in a narrow tabular mass astride Oat Canyon 7 mi. east of Lindsay. The limestone mass, set on edge between schist and granite walls is 75-125 ft. wide and can be traced for a mile. Oat Canyon approximately bisects the length of the limestone mass, which strikes N. 45°-50° W. and stands nearly vertical. Developed by one quarry 75x135 ft. in plan developing a face over 100 ft. high. This was last operated about 1930. Rock was quarried to supply lime-burning plants and sugar refineries. Probably the second largest producer in Tulare County. Four typical samples taken by O. E. Bowen and C.H. Gray in 1954 in the vicinity of the quarry yielded the following analyses; Abbott A. Hanks, Inc., of San Francisco, analysts: Oxide — No.1 — No.2 — No.3 — No.4 — No.5 SiO_2 — 0.34 — 0.60 — 0.90 — 0.26 — 0.46 Fe_2O_3 — 0.08 — 0.19 — 0.23 — 0.11 — 0.08 Al_2O_3 — 0.42 — 0.53 — 0.75 — 0.35 — 0.20 CaO — 54.72 — 34.44 — 53.23 — 54.39 — 54.54 MgO — 0.46 — 17.16 — 1.26 — 0.61 — 0.47 P_2O_5 — 0.06 — 0.04 — 0.01 — 0.01 — 0.05 CO_2 (calc.) & H_2O — 43.9 — 47.1 — 43.6 — 44.9 — 44.2 (Franke 30:447; Laizure 23:529; Logan 47:340-341.)
	Three Rivers	Not determined					"At Three Rivers, 25 mi. east of Visalia a deposit of blue-black marble suitable for burning lime and for building purposes." (Aubury 06:108.) Probably now adjacent to or else part of the Blossom Peak deposit, which see.

LIMESTONE, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Universal Silicate Stucco and Lime Products Co.						Obtained limestone from deposit now known as Simons. which see (Franke 30:446-447; Logan 47:341).
	Valley Lime Co.						See Simons (Franke 30:447; Logan 47:340).
	White Chief						See under Zinc. Large mass of limestone in Mineral King district. (Tucker 19:918.)
128	Worth (Boydson Bros.)	Not determined	NW¼13	22S	28E	MD	Part of a lens of white, coarsely crystalline limestone striking N. 10°-20° E. and standing nearly vertical. Mass ranges from 75-150 ft. in width, is more than 1000 ft. long. A quarry about 25x25 ft. in plan and 30 ft. deep has been developed in the southern part of the lens; this has been the third largest producer in the county but has been idle since 1925. Some of the rock was crushed for agricultural limestone; some was burned into lime (Franke 30:444-445; Logan 47:336). Much of the rock is more than 98 percent $CaCO_3$. The following samples collected by O.E. Bowen and C.H. Gray in 1954 and analyzed by Abbott A. Hanks, Inc. of San Francisco are typical of the rock in the deposit.

Oxide	Sample 1	Sample 2	Sample 3
SiO_2	0.36	0.52	0.20
Fe_2O_3	0.17	0.11	0.05
Al_2O_3	0.53	0.51	0.29
CaO	53.65	54.35	54.52
MgO	1.10	0.55	0.45
P_2O_5	0.12	0.06	0.05
CO_2 (calc.) & H_2O	44.1	43.9	43.4

MAGNESITE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Adeline (Adelaide)	Not determined	24	20S	27E	MD	Located $6\frac{1}{2}$ mi. east of Lindsay. A 2-ft. vein of magnesite in serpentine; strike east, dip 40° N. Developed by a 252-ft. adit. Twenty men employed in 1916; shipped 50 car loads. (Bradley 25:106; Franke 30:453; Tucker 19:923.)
	American Magnesite Company						Formerly California Magnesite Co. Operated custom calcining plant during World War I; supplying American Refractory Co., Joliet, Illinois. In 1920 sold to Sierra Magnesite Co., which see. (Bradley 25:106.)
129	Alcorn and Prindle	Mineral rights held by Western Chemical Division, Food Machinery and Chemical Company, Newark. Surface rights not determined	31	21S	29E	MD	Part of lands formerly controlled by Sierra Magnesite Co., which see. A 160-acre lease about 8 mi. east of Porterville. Series of narrow parallel veins of magnesite in serpentine. Developed by open cuts. (Tucker 19:923.)
130	Avery	Not determined	6	22S	29E	MD	Steep-dipping and flat-lying magnesite veins in serpentine; maximum thickness 2 ft. Developed by a 100-ft. and a 75-ft. adit. Four men were employed in 1916. (Tucker 19:923.)
	Bartlett						W.P. Bartlett, Porterville, one of earliest operators in what is probably now known as the Porterville deposit, which see. (Also see Bartlett lease and Simmons Ranch.) (Aubury 06:333-334.)

MAGNESITE, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Bartlett Lease						See Simmons Ranch (Tucker 19:923-924.)
131	Blue Crystal	S.A. Boggs, Lindsay (1925)	24	20S	27E	MD	Located on east side of Round Valley, $6\frac{1}{2}$ mi. east of Lindsay. Three veins of magnesite up to 2 ft. wide in brown serpentinized peridotite. Veins strike northwest, dip steeply, and are about 50 ft. apart. Developed by open cuts; also a 100-ft. adit and a 140-ft. adit. Twenty men employed in 1916. Average monthly production 300 tons. (Bradley 25:106-107; Franke 30:454; Laizure 23:531; Tucker 19:924-925.)
132	Bolam and Pinger	Not determined	18	21S	28E	MD	Located on Putnam and Gill Ranches, 4 mi. northeast of Porterville. Series of parallel magnesite veins 1 to 2 ft. wide in serpentine, strike N. 50° W., dip 50° SE. Developed by open cuts and short adits. Ten men were employed in 1916. (Tucker 19:925.)
	Burr Bros. Lease						See Cross Ranch (Bradley 25:107; Tucker 19:926).
	California Magnesia Co.						See Porterville (Bradley 25:107,111).
	California Magnesite, Camp 4	Not determined					Lee Gill Ranch, 5 mi. east of Strathmore at 1180 ft. elevation. Magnesite veins in schistose serpentine. (Tucker 19:926.)
	California Magnesite, Camp 2 and 3	Not determined	18	21S	28E	MD	Lee Gill Ranch, $4\frac{1}{2}$ mi. northeast of Porterville on west slope of the range of foothills lying west of Frazier Valley. Two systems of parallel veins in serpentinized

MAGNESITE, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B. & M	
	California Magnesite, Camp 2 and 3 (continued)						peridotite. One parallel set strikes N. 45° W., the other N. 10° W.; dips are about 50° S. The maximum width is about 2 ft. Probably part of Porterville, which see. (Tucker 19:926.)
133	Chamberlain Ranch	Not determined	3,10	23S	28E	MD	Chamberlain Ranch about 8 mi. southeast of Porterville. Narrow, irregular magnesite veins 6 to 12 in. wide. (Bradley 25:107; Franke 30:454; Tucker 19:926.)
134	Cross Ranch (Burr Bros. Lease)	Mrs. Florence Cross	19	19S	27E	MD	About 3 mi. northeast of Lindsay. Narrow irregular veins of magnesite in brown serpentinized peridotite. Veins strike northeast. Developed by a series of short tunnels and open cuts. About 26 men employed in 1916. (Bradley 25:107; Franke 30:454; Tucker 19:926.)
	Davis Lease						See Montgomery (Bradley 25:121; Tucker 19:926-927).
	Deer Creek (Langley-Cook Lease)	Claude Slaughter, Success (1956)	21,22 28	22S	28E	MD	Carroll Ranch south of Deer Creek. Perpendicular veinlets of magnesite up to 2 ft. in width. Developed by open cuts and by two 200-ft. adits on west slope, and a 200-ft. adit on the east slope; also a shaft. Some magnesite nickel-bearing. (See also under Nickel.) (Bradley 25:107; Franke 30:454; Hess 08:39-40; Tucker 19:927.)
135	De Moulin (Magnesite Refractories, Stewart)	Not determined	N½12	21S	27E	MD	Located 3 mi. north of Porterville. Most active in 1916-17 during which time 3648 tons of crude magnesite produced. Two systems of veins; one strikes north, dips 60° W., the other strikes east. The north-striking veins

MAGNESITE, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	De Moulin (continued)						were 2 to 4 ft. wide and continuous whereas the east-striking veins were narrow and irregular. The largest stope was 250 ft. long. About 125 ft. of backs were developed by several adits. (Bradley 25:107-108; Tucker 19:936.)
	Dinuba Magnesite (Weissman Lease)	Not determined					Near Dinuba, near Fresno County line. Reported shipping 2500 tons during 1916 (Bradley 25:108; Franke 30:454).
136	Dumont	Not determined	10	19S	27E	MD	Located 5 mi. east of Exeter. Series of steep-dipping magnesite veins in brown serpentinized peridotite. The most prominent vein was 4 ft. wide, striking N. 60° W., dipping 65° NE. The ore was high in silica. Several hundred tons of crude reported shipped. Six men were employed in 1916. (Bradley 25:108-109; Franke 30:454; Tucker 19:927.)
137	Duncan	Not determined	30 25	21S 21S	29E 28E	MD MD	Duncan Ranch, 6 mi. east of Porterville. Extensive outcrops of magnesite veins. Some development work by California Magnesite Co; Small acreage leased by Hawley Pulp and Paper Co. (Bradley 25:108-109; Franke 30:454; Tucker 19:927.)
	El Mirador Magnesite Co.						Organized 1925 to operate Adeline (Bradley 25:106).

MAGNESITE, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
138	Fairview	Not determined	30	20S	28E	MD	Foothills, 5 mi. east of Lindsay. A 12- to 18-in. vein developed by an adit; elevation 950 ft. Four men employed in 1916. (Bradley 25:109; Franke 30:454; Tucker 19:928.)
	Gill Ranch deposits (California Magnesite Co., Sierra Magnesite Co., Tulare Mining Co.)	Lee Gill Ranch	7,18	21S	28E	MD	Northwest of Porterville. Magnesite deposits at several places on this ranch along the belt of magnesite-bearing serpentine that trends north and northwestward from the Porterville deposit. Portions of this ranch leased by California Magnesite Co., and by Tulare Mining Co. All deposits later leased by Sierra Magnesite Co. See under company names. (Bradley 25:109-110; Franke 30:454; Laizure 23:531; Tucker 19:926.)
	Harker						See Porterville (Bradley 25:110-117).
139	Hamilton	Not determined	32	18S	27E	MD	Hamilton Ranch, Yokohl Valley. Series of 6- to 12-in. veins of magnesite striking N. 20° W. in serpentinzed peridotite. The serpentine body is about 150 ft. wide. The veins are parallel to the long axis of the serpentine body. (Franke 30:454; Tucker 19:928.)
140	Hawley	Not determined	W½30	21S	29E	MD	Located 6 mi. east of Porterville; adjoined Tulare Mining Co. on west. Two systems of magnesite veins, one striking N. 50° W., the other west. Dips range from 45° to 60° N. Developed on three levels by adits. Ore shipped to Pacific Carbonic Gas Co., Berkeley, California. Ten men employed in 1916. (Bradley 25:117-118; Laizure 23:531; Tucker 19:928-929.)

MAGNESITE, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Hayden	J.T. Hurst, 363 South Olive Street, Los Angeles (1930)					Hayden Hill. Stockwork of magnesite veins. Produced 930 tons in 1917. (Bradley 25:118; Franke 30:449.)
141	Headburg	Not determined	11	20S	27E	MD	Foothills east of Round Valley, $4\frac{1}{2}$ mi. east of Lindsay. Stockwork of magnesite veins developed by open pit. (Bradley 25:118; Franke 30:454; Tucker 19:936.)
	Joyner	Not determined					See Merryman (Bradley 25:118).
	Langley - Cook Lease						See Deer Creek (Bradley 25:107.)
142	Lindsay	Mineral rights held by Westvaco Chemical Division, Food Machinery and Chemical Company, Newark. Surface rights not determined.	31	21S	29E	MD	On the south side South Fork Tule River, 2 mi. south of Success. One of the principal sources of magnesite in the county. Operated by Lindsay Mining Co. 1916-18. Incorporated into other holdings of Sierra Magnesite Co. in 1920. More than 33,000 tons of magnesite produced 1916-17 from rather extensive surface and underground workings that reached a depth of 285 ft. below outcrop. Magnesite occurred in veins in serpentinized peridotite. Veins as wide as $3\frac{1}{2}$ ft. were continuous for lengths of 240 to 300 ft. and were stoped through vertical ranges of about 150 ft. (Bradley 25:118-119; 124-125; Franke 30:451; Gale 14:510,511; Tucker 19:929-931.)
	McKiernan	Not determined					West of Lindsay mine. Open cut on a series of 4- to 5-in. stringers. Crude magnesite sold to Sierra Magnesite Co. (Bradley 25:119; Franke 30:454.)
	Magnesite Refractories						See De Moulin (Bradley 25:107-108).

MAGNESITE, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Mentz (Ravalli Lease)	Not determined	SE$\frac{1}{4}$28	22S	28E	MD	Northeast of Terra Bella. Magnesite veins 6 in. to 2 ft. wide. Shipped 65 tons in 1917. (Bradley 25:119; Franke 30:454.)
143	Merryman (Joyner)	Not determined	12 7	19S 19S	26E 27E	MD MD	On southwest spur of Rocky Hill. Series of north-striking veins 1 to 2 ft. wide in serpentine; also stockworks of veins. Developed by adits and open cuts. Shipped about 5000 tons in 1917 and 2500 tons in 1916. (Bradley 25:119; Franke 30:449; Hess 08:49; Tucker 19:931.)
	Mitchell	Not determined	Appr.	19S	26E	MD	Rocky Hill, 2 mi. east of Exeter. Produced 150 tons in 1916. (Bradley 25:121; Franke 30:454.)
	Montgomery (Davis lease)	Not determined	24	20S	27E	MD	About 6$\frac{1}{2}$ mi. east of Lindsay. Series of parallel northwest veins of magnesite in schistose serpentine; maximum width 2 ft. An 18-in. vein striking N. 25° W., dipping 75° SW. is developed by a 100-ft. adit at an elevation of 1000 ft. A parallel vein at 900 ft. elevation is developed by a 150-ft. adit and open cuts. Twenty men were employed in 1916; production in 1916 was 1302 tons of crude ore. (Bradley 25:121; Franke 30:454; Tucker 19:926-927.)
	National Kellastone Company						Associated with Sierra Magnesite Co. Stucco manufacturer. (Bradley 25:133-135; Franke 30:452-453; Laizure 23:531-533, 535.)

MAGNESITE, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Oakland Magnesite	Not determined	7,8 21	21S 22S	28E 28E	MD MD	Northeast and southeast of Porterville Co. controlled two leaseholders. The one adjoining Harker mine taken over by Sierra Magnesite Co. in 1920; other deposit was source of 10,000 tons in 1916-17. This was known as Deer Creek and North mine on the Langley leasehold and possibly is same as Deer Creek, which see under Magnesite. See also under Nickel, as some magnesite in this area was nickeliferous. (Bradley 25:123,129.)
144	Porterville (California Magnesite, Harker)	Not determined	17	21S	28E	MD	On "Porterville Hill" about 4 mi. northeast of Porterville. A major source of magnesite in the county. Magnesite in veins and stockworks in serpentinized peridotite underlying two rounded hills and intervening saddle 300 ft. down. Magnesite mined along hill for more than 2000 ft. Veins 2 to 8 ft. thick and as long as 362 ft.; one vein explored as deep as 500 ft. below outcrop. Prior to June 1916, only crude magnesite produced; magnesite calcined after that date. Peak production 250-300 tons per day in 1917. Operated by Sierra Magnesite Co. 1920-23; by California Magnesite Co. for a short time after. (Aubury 06:333-334; Bradley 25:110-117; Franke 30:448-449; Gale 14:509; Hess 08:40-46; Laizure 23:531; 24:30; Tucker 19:931-935.)
	Ravalli Lease						See Mentz (Bradley 25:119).
	Rex Plaster	Mineral rights held by Westvaco Chemical Division; Food Machinery and Chemical Co., Newark. Surface rights not determined	$S\frac{1}{2}S\frac{1}{2}$ 31	21S	29E	MD	In Success district. Small narrow vein worked by hand in open cuts, principally during 1916-17. Inactive since 1917, although ground taken over by Sierra Magnasite Co. in 1920. (Bradly 25:123,124; Franke 30:499, 450-451.)

MAGNESITE, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Sierra Magnesite Co.	Mineral rights owned by this company retained by Westvaco Chemical Division, Ford Machinery and Chemical Co., Newark. Surface rights disposed and not determined					Company organized in 1920; controlled most of important deposits around Porterville. (Bradley 25:123-135; Franke 30:452-453; Hess 08:46-48; Laizure 23:531-533, 535; herein.)
	Simmons Ranch (Bartlett Lease)						Located 1 mi. south of Simmons Ranch School. Discontinuous veinlets of magnesite up to 2 ft. thick in brown serpentized peridotite. Developed by open cuts and short adits. Twelve men employed in 1916. (Bradley 25:135; Franke 30:454; Tucker 19:923-924.)
	Stewart						See De Moulin (Tucker 19:936).
145	Tulare	Mineral rights held by Westvaco Chemical Division, Food Machinery and Chemical Co., Newark. Surface rights not determined	30,31	21S	29E	MD	About 1 mi. south of Success. Tulare Mining Co. operated to 1921 when property purchased by Sierra Magnesite Co. One of major sources of magnesite on county. Magnesite in typical veins and stockworks in serpentine and recovered from both in surface and underground workings. Both crude and calcined magnesite sold. (Bradley 25:125-129; Franke 30:454; Gale 14:510,511; Hess 08:46-48; Tucker 19:936-940.)
	Tulare	Not determined	$E\frac{1}{2}NE\frac{1}{4}$ 28	22S	28E	MD	Magnesite veins in serpentinized peridotite too narrow for profitable operation. Active in 1917; 6-7 tons per day mined from open cuts. (Bradley 25:135, 137.)

MAGNESITE, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Wood	Not determined	6	19S	27E	MD	Located 3 mi. east of Exeter. Magnesite veins 3 to 12 in. wide occur over a small area. Developed by open cuts. Six men employed in 1916. (Bradley 25:137; Franke 30:454; Tucker 19:940.)
	Weissman lease						See Dinuba Magnesite Co. (Bradley 25:108).

SAND

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Brown Cement Works	D.C. Brown, R.F.D. 3, Box 343A, Tulare (1930)					Inactive. Operated pit on property 2 mi. east of Tulare for use in concrete pipe. (Franke 30:463.)
146	Charter Oaks	Bud Minecke, Visalia	$S\frac{1}{2}SE\frac{1}{4}$ 17	18S	26E	MD	Operating sand pit on St. Johns River, tributary of Kaweah (herein).
	Garland	E. Garland (1930)					Inactive. Operated pit 3 mi. east of Visalia until 1931. (Franke 30:463.)
	McWilliams	Not determined					Inactive. Located 1 mi. northeast of Visalia (Franke 30:463).
	Nelson Concrete Pipe Co.	Not determined					Inactive. Produced sand until 1935 for plant at Strathmore.
	Parker	Not determined					Inactive. About 8 mi. northwest of Visalia on St. Johns River. Sand excavated by dragline from river bottom. Used in roads and glass manufacturing. (Tucker 19:947.)
	Tulare Cement Pipe Co.	Not determined					Inactive. Used local sand until 1931 for concrete pipe plant in Tulare. (Franke 30:464.)
	Tulare County	Not determined					County operated pit near Venice Cove on Klink Road until 1934. (Franke 30:463.)
	Van Cleve Construction Co.	Not determined					Inactive. Used sand from St. Johns River for concrete pipe manufacture. (Franke 30:464.)

SAND AND GRAVEL

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Duggan and Nelson	Not determined					Inactive; removed sand and gravel from Tule River 1931 for use in concrete pipe. (Franke 30:463.)
147	Jeffers	Poplar Irrigation Co., S.A. Ridgway, Secretary, Star Route 2, Porterville (1938)	4	22S	28E	MD	Inactive. Operated on Tule River east of Porterville from 1932-49.
	Middleton-Sequoia Rock Company						Formerly operated present P.C.A. no. 133 pit on Kaweah River near Lemon Cove from 1949-51.
148	Middleton-Sequoia Rock Company	Middleton-Sequoia Rock Co., Porterville	NE$\frac{1}{4}$3	22S	28E	MD	Operate on Tule River east of Porterville (herein).
149	Pacific Cement and Aggregate Company	Kern Rock Co., Bakersfield (1936)	13	20S	27E	MD	Abandoned pit for plant no. 123. Operated on Lewis Creek east of Lindsay from 1935-53.
150	Pacific Cement and Aggregate Company, Plant No. 133	Pacific Cement and Aggregate Co., 400 Alabama Street, San Francisco	W$\frac{1}{2}$SW$\frac{1}{4}$ 35	17S	27E	MD	On Kaweah River north of Lemon Cove (herein).
151	Pacific Cement and Aggregate Company Plant No. 134	Not determined	35	17S	27E	MD	Abandoned. Operated pit on Kaweah River at Terminus Beach 1943-54.
	Pacific Coast Aggregates Co.						See Pacific Cement and Aggregate Company.
	Porterville Cement Pipe Co.	Bob Jurkovich, Main and Date Streets, Porterville					Inactive. Used sand and gravel from Tule River until 1942. (Franke 30:463.)

SAND AND GRAVEL, CONT.

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
152	Quiram and Sons	E.F. Quiram, 406 Garden Street, Porterville	31	21S	28E	MD	Operate on Tule River east of Porterville (herein).
	Sequoia Rock Co.						Formerly operated present P.C.A. no. 133 pit on Kaweah River, Lemon Cove from 1946-49.
	Terminus Beach Rock Co.						Formerly operated P.C.A. no. 134 pit on Kaweah River near Terminus Beach 1949-53.
	Tulare Rock Co.	Not determined					Inactive. Operated pit 5 mi. southeast of Lindsay 1929-35. (Franke 30:464.)

CRUSHED AND BROKEN STONE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Carr Crushed Rock Co.	W.S. Carr, Lindsay					Inactive. Portable crushing plant located 8 mi. northeast of Lindsay on Roeding Ranch. Crushed "Blue Stone" boulders. (Franke 30:463.)
153	Grant	Not determined	S½17	18S	26E	MD	Inactive. About 8 mi. northeast of Visalia. Grant Rock and Gravel Co., operation. Serpentized peridotite blasted by coyote hole method, crushed to minus 2¼". (Tucker 19:946.)
	Sequoia National Park	National Park Service, Sequoia National Park	20	15S	30E	MD	Inactive. Granite quarried for use in park in 1930's.
	Tulare County Rock Pit	Tulare County (1930)					Inactive. County-operated decomposed granite pit about 14 mi. northeast of Porterville. Rock loosened by blasting and shipped by truck and rail. Produced intermittently until 1934. (Franke 30:463.)
	"Porterville White" Granite	Not determined					Inactive. Waste granite from dimension stone quarry operations of McGilvray Raymond Corp. and California Granite Company crushed and sold (See under Dimension Stone).

DIMENSION STONE - GRANITE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Bartlett						Obtained building stone from surface boulders of granite 3 mi. northeast of Porterville. (Aubury 06:54.)
	California Granite Co.						Operated "Porterville White" and "Porterville Black" granite quarries 1915-18. (Franke 30:442-444; Laizure 22:527; Tucker 19:915-916.)
	Dickey	A.L. Dickey, 119 South L, Dinuba (1930)	11	16S	25E	MD	About 2 mi. east of Orosi. Building stone obtained from granite float. Stone is dark gray, medium grained. Used in Bank of America building in Dinuba. (Franke 30:442.)
	Griffith and Owens						See Rock Point. (Crawford 94:3,7; 96:623.)
	McGilvray Raymond Corporation						Operated "Porterville White" quarry from 1928-29 and "Porterville Black" quarry from 1928-33. (Franke 30:442-444.)
	Oakland Granite and Marble Co.						Operated "Porterville Black" quarry from 1930's to 1953.
154	"Porterville Black"	W.W. Gainey, 130 Lunado Way, San Francisco	29	21S	29E	MD	Near Success (Franke 30:442-444; Laizure 22:527; Tucker 19:915-916; herein).
155	"Porterville White"	Not determined	27	21S	28E	MD	About 4 mi. east of Porterville near Success. (Franke 30:442-444; Laizure 22:527; Tucker 19:915-916; herein.)
156	Rocky Point (Griffith and Owen)	Not determined	8	19S	27E	MD	About 4 mi. east of Exeter. (Aubury 06:55-56; Crawford 96:623; Franke 30:444; Laizure 22:527; Tucker 19:916-917; herein.)

SULFUR

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Franklin Canyon	Not determined	Appr.	17S	31E	MD	Located in Franklin Canyon, 2 mi. southeast of Mineral King at 10,000 ft. elevation. A zone of pyrrhotite 4 ft. wide on limestone-granite contact. (Tucker 19:917.)
	Lady Emma	Not determined	Appr.	17S	31E	MD	Located in Monarch Canyon about 2 mi. southeast of Mineral King at an elevation of 10,100 ft. A 4-ft. zone of pyrrhotite trending N. 30° W., dipping 80° N. on limestone-granite contact. (Tucker 19:918.)

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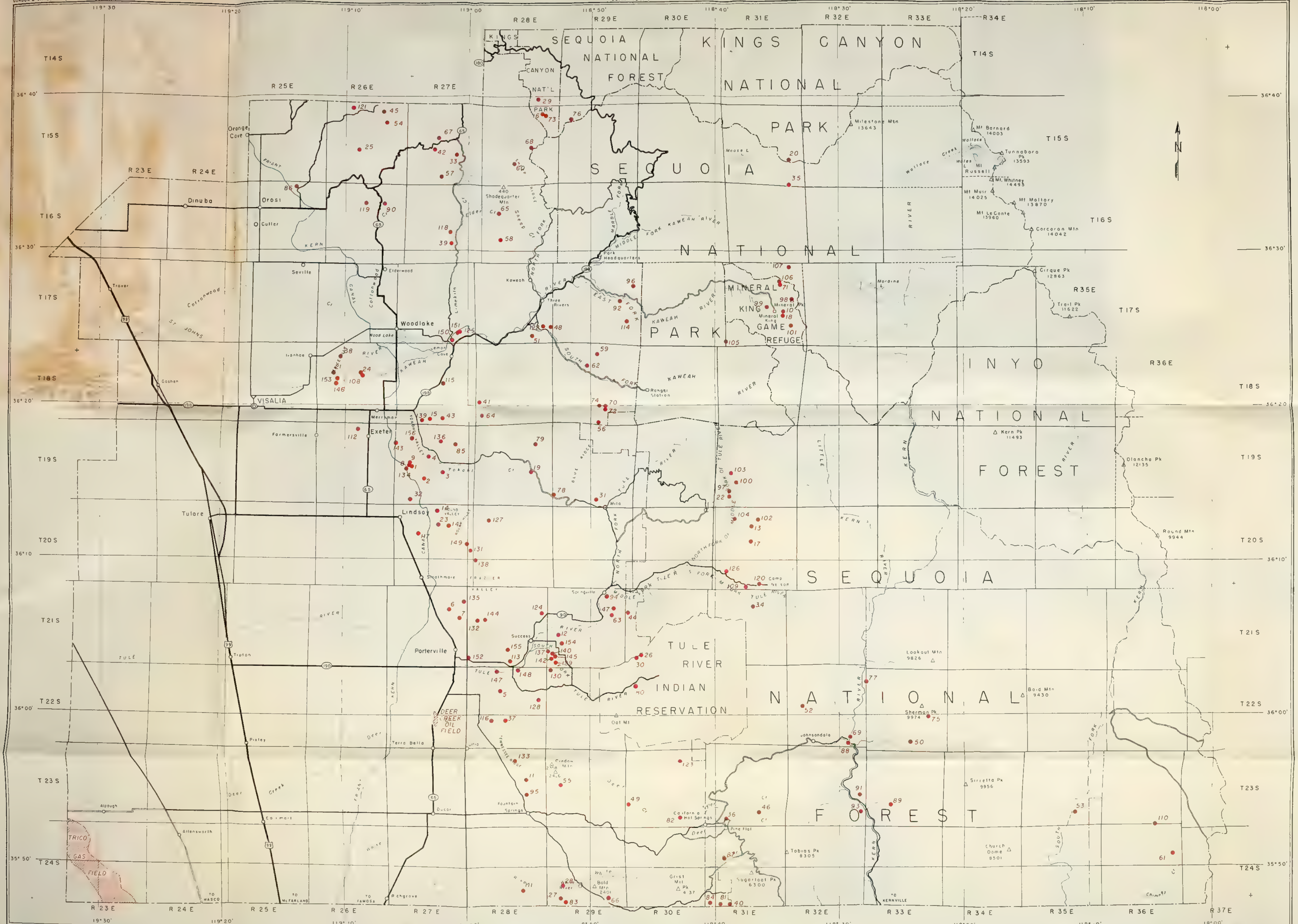

MAP OF TULARE COUNTY, CALIFORNIA, SHOWING MINES AND PROSPECTS
1958

Scale 0 1 2 3 4 5 Miles

Base map prepared from U S Forest Service and California Division of Forestry maps

Map no	Name of property	Location Sec.	T.	R.
	CHROMITE			
1.	Bowlin	20	19S	27E
2.	Earl Smith	20, 28	19S	27E
3.	Gill	22	19S	27E
4.	Gill Ranch	16	19S	27E
5.	Holston	9	22S	28E
6.	James	11	21S	27E
7.	Lewis Hill	13	21S	27E
8.	Sattlefield	20	19S	27E
9.	Waddell	17, 20	19S	27E
	COPPER			
10.	Annie Fox	14	17S	31E
11	Barber No 1	14	23S	29E
12	Barber No 2	19	21S	29E
13.	Barber-Witt	9(?)	20S	31E
14	Gram	3	20S	27E
15	Hamilton	33	18S	27E
16.	Hart prospects	2	15S	28E
17	Iron Capping	16	20S	31E
18	Lions Nest	14	17S	31E
19.	Mankins	23	19S	28E
20.	Oakland Copper	25	15S	31E
21	Page	17	18S	26E
22	Powell	32	19S	31E
23	Round Valley	3	20S	27E
24	Thomas Jacobs	15	18S	26E
	GOLD			
25.	Barton	21	15S	26E
26.	Florence G	30, 31	21S	30E
27	Josephine	31, 32	24S	29E
28	Last Chance	29	24S	29E
29	Redwood Canyon	35	14S	28E
30	Southern Mother Lode	30, 31	21S	30E
	MANGANESE			
31.	Barbour	33	19S	29E
32	Cole	32	19S	27E
33.	Dry Creek	23	15S	27E
	MOLYBDENUM			
34	Griders	10	21S	31E
35	Kaweah	35, 36	15S	31E
		2	16S	31E
36	Wingrove	31	23S	31E
	NICKEL			
37	Deer Creek (nickeliferous magnetite)	21, 22, 28	22S	28E
38	Venice Hill	4, 5, 8, 9	18S	26E
	TUNGSTEN			
39.	Alice Namer	34	16S	27E
40	Anita May	32	24S	31E
41	Baker Lease	30	18S	28E
42	Barrington	21	15S	27E
43.	Baty	34	18S	27E
44	Big Mack	7	21S	30E
45	Bill Waley Indian Allotment	2	15S	26E
46.	Billy Boy group	26, 27, 34, 35	23S	31E
47	Bob Marshall	12	21S	29E
48	Blossom Peak	25	17S	28E
49	Blue Ridge	30	23S	30E
50.	Brush Creek	34	22S	33E
51	Carter	35	17S	28E
52	Carver	22	22S	32E
53	Christmas	25, 26	23S	35E
54	Consolidated Tungsten	11	15S	26E
55	Credaw Mountain	17	23S	29E
56	Crystal Queen	34	18S	29E
57	Cutler	33	15S	27E
58	Davis Ranch	29	16S	28E
59	Eagle (Buckeye)	4	18S	29E
60	Eshom Creek	28	15S	28E
61	Great Western	13	24S	36E
62.	Grey Fox	9	18S	29E
63	Herbert and Crabb	12, 13	21S	29E
64	Hinds Ranch	31	18S	28E
65	Homer Ranch	17, 19, 20	16S	28E
66.	Indian	35	24S	29E
67	J A Barrington	16	15S	27E
68	Kaweah River	22 14, 28	15S	28E
69	Kern River	35	22S	32E
70	Martin	27	18S	29E
71	Mineral King	11	17S	31E
72	Pioneer	27	18S	29E
73.	Redwood Canyon	2	15S	28E
74	Royal Tungsten	27	18S	29E
75.	Sherman Peak	23	22S	33E
76.	Stony Creek	7	15S	29E
77.	Sunnyside	1, 12	22S	32E
		6	22S	33E
78	Thanksgiving	31	19S	29E
79	Tulare County	11	19S	28E
80	Tule Indian Reservation	7	22S	30E
81	Tungstore	32	24S	31E
82	Tyler Creek	35	23S	30E
83	White River Lode	32	24S	29E
84	Wible	31	24S	31E
85	Yokohl Valley	11	19S	27E
	URANIUM AND THORIUM			
86	Bezzerides	3	16S	25E
87	Big Four No. 1	17	24S	31E
88	Chico No 1	35	22S	32E
89	Dead Tree	28, 29	23S	33E
90	Divine No 1 and No 2	11	16S	26E
91	Farmer	24	23S	32E
92	Griffith	14	19S	29E
93	Jay Bird No 1	25	23S	32E
94	Sequoia Ranch	2	21S	29E
95	Tomlee	23	23S	28E
96	Visalia Land and Investment Company	12	17S	29E
	ZINC-LEAD-SILVER			
97	Cedar Hill	29	19S	31E
98	Chihuahua	13	17S	31E
99	Comanche	22	17S	31E
100	Galena Cave	29	19S	31E
101	Lady Franklin	25	17S	31E
102	Prince Albert	3	20S	31E
103	Skylark	20	19S	31E
104	Thunder Shower and Buckhead	5	20S	31E
105	White Chief	31	17S	31E
106	White Horse	11	17S	31E
107	Young America	1, 2	17S	31E
	ASBESTOS			
108.	Hanggi Ranch	15	18S	26E
	BARITE			
109	Camp Nelson	33	20S	31E
110	Paso Baryta	34, 35	23S	36E
		2	24S	36E
	CLAY			
111	Sears Clay	26, 27, 35	24S	28E
112	S P Brick and Tile	3	19S	26E
113	Valencia Heights	34	21S	28E
	FELDSPAR			
114	Brittan Ranch	23, 24, 25	17S	29E
115	Honora Reality	15	18S	27E
	GEM MATERIALS			
116	Deer Creek (chrysoprase)	20, 29	22S	28E
117	Lindsay (chrysoprase)	5	20S	27E
		17	20S	27E
118	Rhodonite	22, 34	16S	27E
119	Stokes Mountain (chrysoprase)	9 10	16S	26E
	GRAPHITE			
120	Camp Nelson	34	20S	31E
121	Drum Valley	4, 5	15S	26E
	LIMESTONE			
122	Blossom Peak	25	17S	28E
123	Devil s Thumb	2 3 10, 11,14	23S	30E
124	Holdridge	13	21S	28E
125.	Lemon Cove	35 36	17S	27E
126	Moorehouse Creek	29, 30, 31 32	20S	31E
127	Simons	6	20S	28E
128	Worth	13	22S	28E
	MAGNESITE			
129	Alcorn and Prindle	31	21S	29E
130	Avery	6	22S	29E
131	Blue Crystal	24	20S	27E
132	Balam and Pinger	18	21S	28E
133	Chamberlain Ranch	3, 10	23S	28E
134	Cross Ranch	19	19S	27E
135	De Maulin	12	21S	27E
136	Dumont	10	19S	27E
137	Duncan	25	21S	29E
138	Fairview	30	20S	28E
139	Hamilton	32	18S	27E
140	Hawley	30	21S	29E
141	Headburg	11	20S	27E
142	Lindsay	31	21S	29E
143.	Merryman	12	19S	26E
		7	19S	27E
144	Porterville	17	21S	28E
145	Tulare	30, 31	21S	29E
	SAND AND GRAVEL			
146	Charter Oaks	17	18S	26E
147	Jeffers	4	22S	28E
148	Middletons-Sequoia	3	22S	28E
149	Pacific Cement and Aggregates (for Plant 123)	13	20S	27E
150	Pacific Cement and Aggregates (for Plant 133)	35	17S	27E
151	Pacific Cement and Aggregates (for Plant 134)	35	17S	27E
152	Quiram and Sons	31	21S	28E
	STONE, CRUSHED AND BROKEN			
153	Grant	17	18S	26E
	STONE DIMENSION			
154	Porterville Black	29	21S	29E
155	Porterville White	27	21S	28E
156.	Rocky Point	8	19S	27E

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

CALIFORNIA JOURNAL OF MINES AND GEOLOGY

Volume 54, Number 4
OCTOBER 1958

CONTENTS

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

NOTICE

This, the October 1958 issue [Volume 54, Number 4] of the *California Journal of Mines and Geology*, is the last issue of the *Journal* series. What would have been the January 1959 issue [Volume 55, Number 1] instead will be the *Fifty-Fifth Report of the State Mineralogist*, continuing the original series that dates back to 1880.

It is planned that future *Reports of the State Mineralogist* will contain the *Annual Report of the State Mineralogist, Chief, Division of Mines*, and the annual statistical reports on mineral production. Other types of reports formerly published in the *Journal* will be absorbed by other of the Division's publications series.

These changes are being effected to improve the publication program of the Division of Mines, and so to provide better service to the public. They will enable the Division to initiate a more realistic pricing system, and will facilitate publication of the various reports.

STATE OF CALIFORNIA
GOODWIN J. KNIGHT, Governor
DEPARTMENT OF NATURAL RESOURCES
DeWITT NELSON, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO 11
GORDON B. OAKESHOTT, Chief

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OF
MINES AND GEOLOGY

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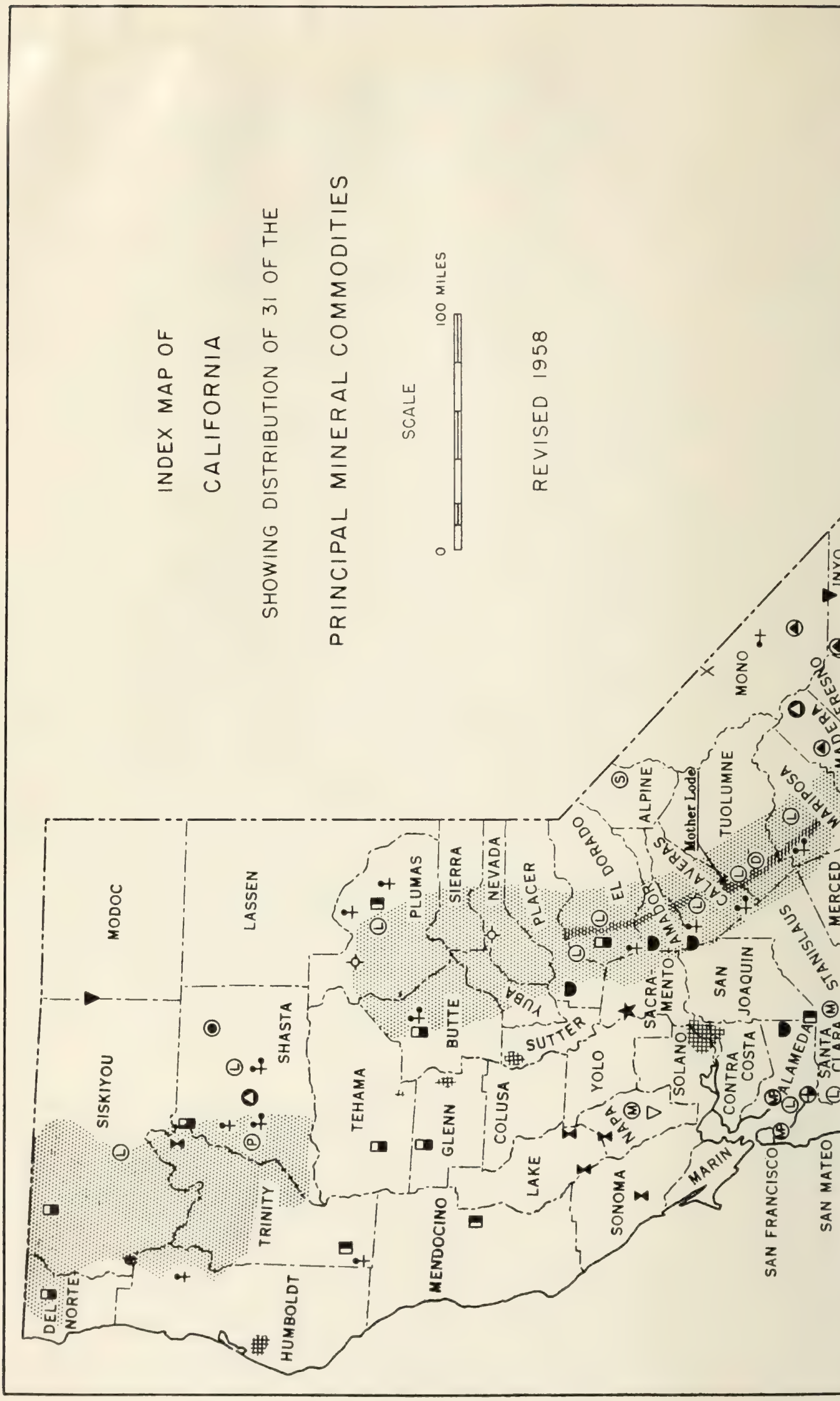
Cypress and Lanning, Redding

The Division of Mines maintains at its headquarters offices in San Francisco a technical library containing several thousand books and scientific journals on geology, mining, mineralogy, chemistry, metallurgy, and related subjects; a reading room containing periodicals devoted to the petroleum and mining industries, and newspapers from the mining centers of the state; exhibits of minerals, rocks, mine models, etc.; a service laboratory for the determination of California minerals; and a conference room with a mining engineer in attendance to serve the public and to sell publications of the Division. Publications are also sold at the Los Angeles, Sacramento, and Redding branch offices.

In addition to oral conferences in the offices of the Division of Mines, information concerning the mineral resources, mineral industry, geology, and mining operations of California is distributed to the public by means of publications, monthly releases, and letters. Each letter of inquiry received by the Division is answered by the technical staff member best qualified to do so.

The principal publications of the Division of Mines are **Bulletins, Special Reports,** and the quarterly **California Journal of Mines and Geology,** issued in January, April, July, and October of each year. With this issue (October 1958), the **California Journal of Mines and Geology** is being discontinued; it will be superseded by an annual **Report of the State Mineralogist,** the 1959 issue of which will carry the number 55. **Mineral Information Service** is a monthly news release concerning the mineral resources and industry of California, designed to inform the public of discoveries, operations, markets, statistics, and new publications. A list of available publications will be sent free upon request.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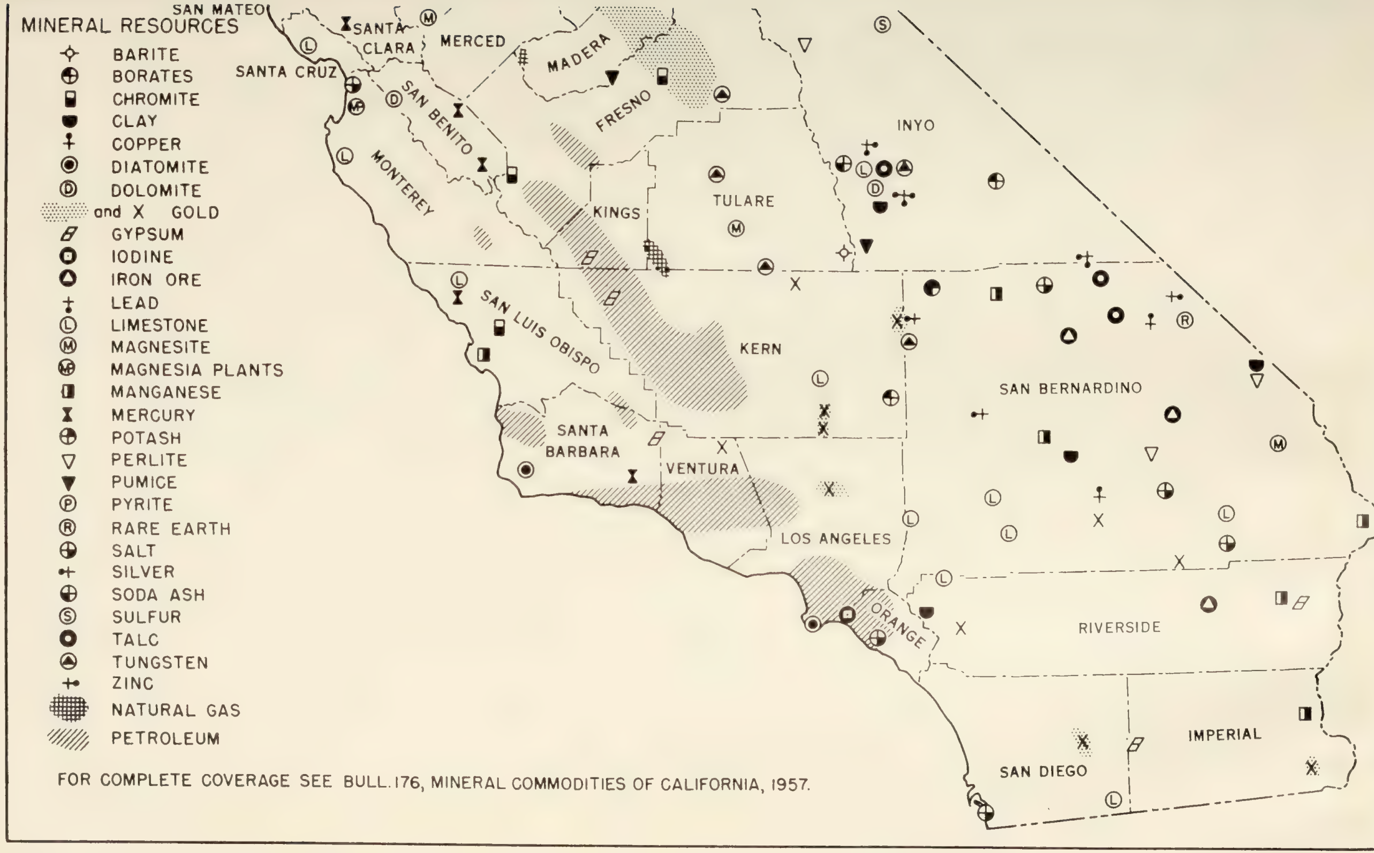
CALIFORNIA
SHOWING DISTRIBUTION OF 31 OF THE
PRINCIPAL MINERAL COMMODITIES
SCALE
0
100 MILES
REVISED 1958
DEL NORTE
SISKIYOU
MODOC
LASSEN
SHASTA
TRINITY
HUMBOLDT
TEHAMA
PLUMAS
BUTTE
SIERRA
NEVADA
PLACER
YUBA
SUTTER
GLENN
COLUSA
MENDOCINO
LAKE
YOLO
SONOMA
NAPA
SOLANO
MARIN
SACRA-MENTO
EL DORADO
AMADOR
ALPINE
CALAVERAS
Mother Lode
TUOLUMNE
MONO
SAN JOAQUIN
CONTRA COSTA
ALAMEDA
SAN FRANCISCO
SAN MATEO
SANTA CLARA
STANISLAUS
MERCED
MARIPOSA
MADERA
FRESNO
INYO



FOR COMPLETE COVERAGE SEE BULL. 176, MINERAL COMMODITIES OF CALIFORNIA, 1957.

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PLATES

MINES AND MINERAL RESOURCES OF CONTRA COSTA COUNTY, CALIFORNIA †

By Fenelon F. Davis * and Harold B. Goldman *

OUTLINE OF REPORT

Illustrations

ABSTRACT

Contra Costa County, in the Coast Ranges of central California, lies northeast of San Francisco and Oakland in the San Francisco Bay area. Its 734 square miles include land as low as the delta and tidal flats along San Francisco Bay to mountains as high as Mount Diablo, some 3,849 feet above sea level. Rocks typical of the central Coast Ranges, ranging in age from Upper Jurassic to Recent, are exposed in

† Manuscript submitted for publication June 2, 1958.
* Mining Geologist, California State Division of Mines.

the county; on the flanks of Mount Diablo, exceptionally thick sections of Cretaceous and Tertiary rocks may be seen. Mount Diablo itself is a plug of Franciscan (Upper Jurassic) ultrabasic igneous, sedimentary and metamorphic rocks which has been thrust upward through the overlying Cretaceous rocks. The Cretaceous and Tertiary strata of the county have been compressed into a series of northwest-trending folds well exposed near Mount Diablo, and in the hills between the mountain and San Francisco Bay.

The value of the total recorded mineral production for the county, 1894-1956, is $98,641,031. During 1956, mineral production was valued at $5,184,878, ranking the county twenty-second among California's 58 counties. The mineral commodities produced during 1957 were clay, natural gas, peat, sand, stone, and sulfur and hydrogen sulfide gas from petroleum refineries. In the past, substantial quantities of cement, coal, mercury and mineral water were marketed as well as small amounts of pumice.

Stone quarries in Contra Costa County have for many years supplied crushed rock, riprap, and fill material for the construction industries of the East Bay area. Eight quarries and rock plants were operating during 1957, producing sandstone and metavolcanic rock from the Franciscan group (Upper Jurassic), volcanic rock from the Moraga formation (Pliocene), and sandstone from the Monterey and San Pablo groups (Miocene).

The Henry Cowell Lime and Cement Company operated a cement plant southeast of Concord from 1909 to 1946, using travertine-limestone and clay mined on nearby Lime Ridge. The plant was closed when the limestone deposits were depleted.

An estimated 3,500,000 tons of sub-bituminous coal was mined from the Domengine formation (Eocene) in the northern foothills of Mount Diablo before the mines were closed in 1902. Competition from petroleum products forced the cessation of coal mining.

Mercury production has been intermittent since about 1875, the Mount Diablo mine being the only producer. Total recorded production was over 11,000 flasks, most of which was produced between 1938 and 1946. This deposit is associated with hydrothermally altered serpentine of the Franciscan group, and is unique in having metacinnabar as an abundant primary mineral.

Large quantities of clay shale, suitable for use in the manufacture of face and common brick and cement, have been mined from Jurassic, Cretaceous, and Tertiary strata. Virtually unlimited reserves of this type of material are available. Two brick plants have been operating continuously for many years using clay mined in the county.

Natural gas from Eocene sands underlying the northeastern part of the county is produced from seven wells, which tap the southern end of the productive structure of the Rio Vista gas field, the largest dry natural gas field in California.

Sand for use in asphalt plants is mined from sand dunes of Recent age, east of Antioch along the south bank of the San Joaquin River. Sandstone of the Domengine formation, which crops out on the northeast flank of Mount Diablo, was mined for glass sand and clay-free foundry sand; and, in the past, large quantities were mined south of

Brentwood for glass manufacturing. Seven sand properties were producing in 1957.

An extensive mineral processing industry is centered in the county. Petroleum refining is the leading industry; refineries are at Richmond, Oleum, Martinez, and Associated. The only lead smelter on the Pacific Coast is operated at Selby by the American Smelting and Refining Company. Refractories are manufactured at Pittsburg from California clays. At Richmond, mineral wool is produced from copper slag; pyrite is roasted and the sulfur dioxide gas is recovered for the manufacture of sulfuric acid. The furnace calcine from the latter operation is stockpiled for the ultimate recovery of gold and silver it contains in small quantities.

INTRODUCTION

Contra Costa County is in the Coast Ranges of central California. Its shores touch the tidewater of northern San Francisco Bay, San Pablo Bay, Carquinez Strait, Suisun Bay and the delta waters of the Sacramento-San Joaquin River system. The county adjoins Berkeley and Oakland along their eastern borders and is 15 miles east of San Francisco by automobile via the San Francisco-Oakland Bay Bridge.

Contra Costa, meaning "opposite coast," was the name applied to the land across the Bay by the early settlers of San Francisco, though the name lost some of its significance when Alameda County was formed from the western part in 1853.

Numerous tribes of Indians lived and wandered through the area previous to the advent of the first white men. Among these tribes were: The Bolbones of Mt. Diablo; the Pulpunes of Marsh's grant; the Alcalanes of Moraga Valley; the Carquinez and the Huchones near Carquinez Strait; the Chalbones, Comistas, Coyobases, Ompenis, Pescadores and Tarquimes of the delta and slough areas in the eastern and northeastern part of the present county (Purcell 1940). The culture of these tribes apparently failed to attain a very high state of development since few of the relics so typical of many advanced aborigines are found. In general the Indians proved friendly to the early explorers and eventually found employment on the ranchos during the succeeding periods.

In 1772, an expedition from Monterey under the leadership of Acting Governor Don Pedro Fages was sent to the area in search of a land route to Point Reyes, thus beginning Spanish interest in the region. Governor Fages was followed in 1776 by Captain de Anza and by the Moraga expeditions of 1796 and 1810. Captain Moraga's trips were made in pursuit of Indians who had fled a life of discipline and domesticity at the San José Mission.

Mexico achieved her independence from Spain in 1821. During the succeeding 25 years a program of colonization was pursued which led to the establishing of vast ranchos where cattle raising was the principal occupation. Two of the first land grants were made in 1823 to Francisco Castro (San Pablo Rancho) and to Ignacio Martinez (Pinole Rancho).

Other early grants were the ranchos of San Ramon, Acalanes, Lagunas Palos Colorados, Briones and Monte del Diablo. In 1837 Dr. John Marsh purchased Rancho Los Meganos and became the first native American citizen to reside permanently in the county.

California severed her dependence upon Mexico in 1846 and after a short period of independence was ruled by a military governor until admitted into the Union in 1850. Contra Costa County was officially established on February 18, 1850, as one of the original 27 counties of the state. As first constituted, it included most of Alameda County and Santa Clara Counties. Only slight changes in the county boundaries have been made since these counties were formed.

About 1847 wheat was first planted near Lafayette, beginning an era of agriculture that spread the culture of wheat throughout the county; within 25 years over half the acreage of the county was sown to this profitable crop. The peak of production was reached in 1889 when 40 million bushels were produced with Port Costa the focal point in marketing operation. Although small orchards and vegetable gardens were a part of each rancho, as an industry they were not economically important until 1852. From their start in Alhambra Valley, they spread throughout the county and eventually replaced grain as the principal source of agricultural income.

Lime kilns erected near Pacheco in 1854 allowed establishment of a foundry (where the first steam plow was built) in 1859. The mining of coal began about 1860 and was an important industry during the ensuing 40 years. The completion of the Central Pacific Railroad in 1877 spurred industrial development; plants were built to make brick, explosives, and paper, to can fish, and to process ores.

The modern industrial period began about the turn of the century, when the increasing use of oil in industry provided a market that made oil refineries at key points in the county feasible. Modern brick plants, a steel mill, railroad shops, and numerous chemical and related industrial facilities were built after the refineries, many of them dependent upon or related to the refining of petroleum.

GEOLOGY

Contra Costa County lies in parts of two geomorphic provinces. The major portion of the county is in the Coast Ranges province, with a small portion of the eastern end within the Great Valley.

The oldest rocks in Contra Costa County are part of the Franciscan-Knoxville group of Jurassic-Cretaceous age. These are predominantly of marine sedimentary origin with lesser amounts of submarine volcanic and ultramafic intrusive rocks. Overlying this assemblage are marine and continental sedimentary rocks of Cretaceous and Tertiary age, and Tertiary volcanic rocks. Quaternary alluvial deposits overlap the Tertiary strata in the northern and eastern portion of the county.

Rock Formations and their Associated Mineral Resources

Franciscan-Knoxville Group. The Franciscan-Knoxville group (Jurassic-Cretaceous) includes a thick section of marine strata with associated intrusions of basic igneous rocks. The beds are primarily sandstone of the graywacke type with lesser amounts of interbedded shale, siltstone, and chert. The group is exposed in the central portion of Mount Diablo, on Potrero San Pablo west of Richmond and on the western slope of the Oakland-Berkeley Hills.

All the metallic mineral deposits of Contra Costa County, including mercury, chromite, manganese, gold, silver, and copper, are found

within the Franciscan-Knoxville rocks, as well as such non-metallic mineral commodities as asbestos, clay, and stone.

Cretaceous Sedimentary Rocks. Cretaceous strata occur southeast of Crockett, and in a belt extending to the southeast from Mount Diablo. Included in this belt are Upper and Lower Cretaceous interstratified shale and sandstone, and some conglomerate. The Cretaceous shale is used in brickmaking at Port Costa.

Tertiary Sedimentary Rocks. Tertiary rocks comprise the major portion of the outcrops in Contra Costa County. Eocene and Paleocene sandstone, shale, and conglomerate occur in a northwest-trending belt on the northeast flank of Mount Diablo extending from Carquinez Strait to the San Joaquin Valley. The most economically significant Eocene formation is the Domengine from which coal, glass sand, and clay have been produced in the past; foundry and special sand are now being mined near Cowell and south of Antioch.

Natural gas production from the Rio Vista gas field is obtained from sandstone lenses in the Eocene Nortonville formation.

Miocene shale, chert, and sandstone crop out in a broad southeast-trending belt extending from San Pablo Bay and Carquinez Strait through Walnut Creek to the southwest side of Mount Diablo. Stone is obtained from the more massive sandstone beds near Walnut Creek and Pacheco.

Pliocene siltstone, claystone, shale, and conglomerate occur in a zone several miles wide in the western portion of the county extending from San Pablo Bay to the Alameda County line and along the northeast flank of the Los Medanos Hills near Pittsburg.

Tertiary Volcanic Rocks. Flow-rocks of the Moraga formation crop out along the western county line northeast of Oakland. Considerable quantities of stone have been produced from this formation near Orinda.

The Lawlor tuff on the north flank of Los Medanos Hills was a source of pumice in the past. The Pinole tuff near Pinole also constitutes a potential source of pumice.

Quaternary Sedimentary Rocks. Recent windblown sand dunes on the south side of the Sacramento River near Antioch have been a source of asphalt sand for many years; Recent travertine deposits overlying the Eocene sandstone near Cowell have been a source of limestone for cement. Peat is produced in moderate quantities from the Recent soils of the delta region.

Structure

In general, the sedimentary rocks underlying Contra Costa County have been compressed into a series of northwest-trending folds paralleling the general trend of folding in the Coast Ranges province. The largest fold in Contra Costa County is the Mount Diablo anticline which extends from Tracy northward about 55 miles through Mount Diablo across the Carquinez Strait. The crest of the anticline is in the vicinity of Mount Diablo where a central mass of igneous and metamorphic rocks of the Franciscan-Knoxville group has been thrust up through the axial zone of the anticlinal uplift. On the northside of Mount Diablo not less than 43,000 feet of Jurassic, Cretaceous, and Tertiary strata are exposed constituting one of the most complete stratigraphic sequences in the Coast Ranges.

The smaller folds lying west of Mount Diablo are bounded on the west by the northwest-trending Hayward fault along the front of the Oakland-Berkeley Hills.

Geologic History

The oldest rocks in Contra Costa County are sedimentary and volcanic ones deposited in marine environments, and intrusive serpentinized peridotite—all part of the Franciscan-Knoxville group of Jurassic and Cretaceous age.

The present land mass of the county was occupied, during the time these rocks were deposited, by a shallow sea, into which was poured large quantities of coarse, arkosic sand derived from the weathering of Cascadia, an ancient land mass lying west of the present California coast line. The continuous filling of the sea by sand was interrupted occasionally by an underwater volcanic explosion that threw volcanic debris onto the sea floor, or by the more quiet flow of lava onto the bottom of the sea, where it consolidated into pillow basalt. Besides the sand and volcanic products, colloidal silica was added to the sea water, eventually consolidating as chert beds. Associated with these beds are intrusive bodies of basic rocks that were later altered to serpentine.

Altogether, the medium- and fine-grained materials deposited in the trough during the Cretaceous period finally reached a total thickness of 32,000 feet in the Contra Costa area, and even more in other parts of the Coast Ranges. The elapsed time for this action was about 50,000,000 years, followed by a time of local mountain building and partial retreat of the Cretaceous sea. The Mount Diablo area, in particular, was elevated and partly eroded.

The early Tertiary period in the county was characterized by a series of advances and withdrawals of the Tertiary seas, the disappearance of the western land mass (Cascadia), and erosion of the Sierra Nevada to low relief. In Paleocene and Eocene time the land began to sink and the sea expanded over much of the area, reaching its greatest extent near the close of the Eocene epoch. The climate became warm and humid, leading to the formation of coal deposits. Deep chemical weathering resulted in the deposition of high-silica sands of the Domengine formation. Near the end of Eocene time, mountain building again resulted in local emergence of the land. Folding in the vicinity of Mount Diablo exposed 4,000 feet of Eocene sedimentary rocks.

The Miocene epoch was introduced by subsidence of the land areas which progressed during that epoch with the development of definite basins of deposition. The middle Miocene sea occupied much of the county and extended to Mount Diablo which became entirely submerged by the end of Miocene time. Widespread uplift during the upper Miocene caused withdrawal of the sea from a large part of the area. The Berkeley Hills were elevated but the Mount Diablo area remained below sea level to the end of the Miocene epoch.

The Pliocene was the most important epoch of mountain building in the Coast Ranges since the Nevadan revolution of the Jurassic period. In Contra Costa County the Pliocene is represented chiefly by continental sediments, indicating an emergence of the land, and by volcanic rocks. Near the close of the Pliocene, all of the older rocks were folded, faulted, and uplifted to form the nucleus of the topographic units we recognize today. Many small basins of sedimentary deposition were

destroyed, and the sea was driven from the area. The Diablo Range, which through the earlier periods had occasionally been elevated above the level of the sea, was now folded into a major anticlinal structure.

After the close of the Tertiary period, erosion set to work on the newly made land areas, and a large volume of sedimentary rock was removed from the axial belt of the Mount Diablo anticline. The unloading of these sedimentary rocks coupled with continued deep-seated lateral stress, forced a sub-circular mass of Franciscan rocks upward as a fault plug through the remaining rock cover in the apex of the anticline. Slightly modified by erosion and landslides during the Quaternary period, this is Mount Diablo as we know it today.

Orogenic movement in the Coast Ranges continued into the Pleistocene epoch. The structural basins of San Pablo Bay and San Francisco Bay were formed during the latter part of this period (Jenkins, 1951). Extensive terrace deposits were formed in the northern part of the county and volcanic rocks, chiefly basalt, issued at isolated localities near Clayton.

The geologic history of the county has been dynamic, with crustal movements continuing to the present time, although now on an apparently reduced scale. The frequent earthquakes originating along such faults as the Sunol-Southampton fault system and the Hayward fault system, are graphic evidence that movement has not yet ceased.

MINES AND MINERAL RESOURCES

The total recorded mineral production of Contra Costa County from 1894 to 1956 is $98,641,031. In addition, coal valued at $14,300,000 was mined from the Mount Diablo coal field between 1867 and 1882. An undetermined amount of mercury was produced prior to 1894.

Contra Costa County ranked twenty-second among the 58 counties of the state in value of mineral production during 1956. Mineral commodities produced that year were valued at $5,174,878 which was an all-time high for the county.

In addition to the mineral commodities of commercial value which the county has produced, the following minerals are listed by Murdoch and Webb (1956) as having been found in the rocks of the county:

actinolite	diallage	metacinnabar
albite	diopside	prochlorite
anauxite	crossite	psilomelane
anthophyllite	enstatite	pyrolusite
apatite	epsomite	römerite
barite	fluorite	rutile
bornite	halotrichite	siderotil
chalcopyrite	kalinite	sphene
chromite	lawsonite	stibnite
cinnabar	marcasite	tremolite
copiapite	melanterite	zaratite

Asbestos

Although asbestos has not been mined commercially within the county, some has been found in the serpentine of the Mt. Diablo area in T. 1 N., R. 1 E., M. D., according to Laizure (1927), and in serpentine at the north end of the Berkeley Hills between North Berkeley and San Pablo. The Berkeley Hills serpentine, associated as it is with

Table 1. Summary of economic geology of Contra Costa County.

Mineral commodity	Geologic formation	Location	Origin	Mode of occurrence
Asbestos	Franciscan-Knoxville group	North end of Berkeley Hills	Alteration of ultra-basic rocks	Thin veinlets in serpentine
Chromite	Franciscan-Knoxville group	Mount Diablo	Magmatic segregations in serpentinized peridotites	Stringers and lenses or disseminated grains in serpentine
Clay	Cretaceous formations	Port Costa	Marine sediment	Thin shale beds interstratified with siltstone and sandstone
	Franciscan-Knoxville group	Point Richmond		
Coal	Domengine	Nortonville and Somersville	Decomposition of plant material and compaction after burial with other marine sediments	Thin coal seams in a sedimentary section of thin-bedded shale, white friable sandstone, and clay
Diatomite	Monterey group (Tice and Claremont shale)	Vicinity of Pinole	Marine sediment composed of diatom remains deposited in shallow water	Thinly stratified interbeds in shale and sandstone overlain by the Pinole tuff
Gold, silver, and copper	Franciscan-Knoxville group	North slope of Mount Diablo in Mitchell Canyon drainage basin	Epithermal (?) veins	Thin veins in metavolcanic rocks
Limestone	Undifferentiated Eocene formations	Southeast of Concord at Cowell	Deposited from hot calcareous springs penetrating the Eocene rocks	Surficial deposits of Travertine overlying Eocene sandstone
	Cretaceous, Orinda, Siesta and Moraga	Exposures within Concord quadrangle	Lacustrine sediment	Thin lentils or lenses in shale
Manganese	Franciscan-Knoxville group	Red Rock Island	Marine chemical sediment	Thin psilomelane layers interbedded with red radiolarian chert and shale
Mercury	Franciscan-Knoxville group	North peak of Mount Diablo near Clayton	Deposited from hot waters from distant magmatic sources in zones of crushing and shearing	In sheared contact zone between sedimentary rocks and intrusive serpentine where the serpentine has been subsequently altered to silica-carbonate rock

Natural gas	Undifferentiated Eocene formations	Bradford Island, Webb Tract, Port Chicago	Formed from hydrocarbons	Broad northwestward trending, faulted, elongated dome. Productive zones in sandstone
Peat	Soil on Recent alluvium	Delta area of Sacramento and San Joaquin rivers	Residuum resulting from incomplete decomposition of vegetable matter	Organic soil
Pumice	Lawlor tuff	Near Pittsburg	Subaqueous deposit of volcanic glass	Pumiceous tuff interstratified with tuff and sandstone beds
	Pinole tuff	Near Pinole and Rodeo		
Specialty sand	Domengine	Cowell, Nortonville, Brentwood	Marine sediment	Sandstone interbedded with shale
	Recent sand dunes	Antioch	Wind-blown sediment	Massive sand dunes
Stone: Sandstone	San Pablo group	Vicinity of Walnut Creek	Marine sediment	Thin bedded, highly jointed, steeply dipping sandstone
	Monterey group: (Sobrante)	Vicinity of Pacheco	Marine sediment	Steeply dipping fossiliferous sandstone
	Franciscan-Knoxville group	Castro Point, Richmond	Marine sediment	Steeply dipping sandstone beds with some thin shale interbeds
Volcanic rocks	Moraga	Orinda	Extrusive flow	Steeply dipping bedded volcanic flow rocks
Greenstone (metavolcanic rocks)	Franciscan-Knoxville group	Mount Diablo near Clayton	Metamorphosed shallow intrusive	Steeply dipping bedded volcanic flow rocks

Table 2. Mineral production of Contra Costa County, 1894-1956.

Year	Brick		Coal*		Lime		Limestone		Mineral water		Miscellaneous stone[1]	Miscellaneous and unapportioned		
	M	Value	Tons	Value	Barrels	Value	Tons	Value	Gallons	Value	Value	Amount	Value	Substance
1894			35,000	$94,000										Quicksilver, 1875-1877 (inc.).[4]
1895			48,635	139,655										
1896	150	$4,500	44,892	118,709					7,600	$3,700	$9,000	1,400 tons	$2,200	Pottery clay.
1897			39,267	105,180					5,000	1,200				
1898	5,000	25,000	47,000	113,340					9,300	3,100				
1899			53,013	131,613					10,000	3,500				
1900			51,248	145,000					12,000	1,900				
1901			35,000	100,000					12,000	1,900				
1902	800	11,600	13,960	31,160					31,200	8,736		31,700 lbs.	3,645	Copper.
1903	2,600	16,000			5,300	$4,500	18,000	$22,500	78,000	19,500				
1904	9,385	67,495			12,187	10,359			78,000	19,000	23,000			
1905	10,979	73,948			20,244	13,925	34,800	43,500	[2]		76,120			
1906	23,267	169,022									75,025			
1907	48,573	403,564			1,413	1,413	22,038	43,038			210,250	2,057 tons	21,870	Asphalt.[6]
												9,500 tons	123,500	Asphalt.[6]
1908	55,844	335,737					9,140	18,282	109,400	5,470	236,047	6,000 tons	7,500	Pottery clay.
												17,085 tons	222,105	Asphalt.
1909	41,033	268,122			14,062	15,468	22,556	42,837	199,800	10,590	233,782		683,392	Unapportioned, 1900-1909.
1910	30,284	199,079			17,338	14,750	22,912	37,064	2,500	375	235,655			
1911	36,463	271,575			11,872	8,645	68,708	46,208	206,500	10,325	257,503			
1912	32,621	283,718			14,870	12,640	25,879	45,291	200,000	10,000	478,162			
1913	30,411	212,953			150,551	127,968	26,259	34,976	192,292	4,989	660,405		921,349	Other minerals.
1914	16,064	129,543	67	268	5,666	4,724	32,657	43,661	364,288	3,643	308,727		658,755	Other minerals.
1915	14,915	139,862	[2]				11,989	14,565	[2]350,000	4,000	397,330		757,748	Asbestos, cement, coal.
1916	16,672	148,730	[2]				[2]		351,724	6,154	363,753		760,423	Cement, clay, coal, limestone.
1917	and tile	172,653	[2]						436,265	8,563	322,507		772,934	Cement and coal.
												100 tons	300	Pottery clay.
1918	and tile	148,831							30,376	3,038	324,884		847,198	Cement and copper.
													193,340	Clay and clay products.
1919		[2]							[2]		275,309		926,909	Cement and mineral water.
												1,743 tons	3,319	Pottery clay.
1920	13,608	312,398									432,654		1,333,682	Cement and mineral water.
													198,248	Clay and clay products.
1921		[2]							600,300	6,099	415,127		1,003,258	Other minerals.
												7,086 tons	12,910	Pottery clay.
1922	and tile	307,749									559,915		1,516,738	Cement, limestone, mineral water.
													281,743	Clay and clay products.
1923		[2]									629,216		1,761,985	Cement, limestone and mineral water.
[illegible]	[illegible]	[illegible]									646,369		1,374,496	Clay (pottery), cement, limestone,

[illegible]											708,159		1,836,020	Clay (pottery), and clay products, cement, limestone, mineral water.
													448,584	Clay and clay products.
1926		[2]					[2]		[2]		766,921		1,395,048	Cement, limestone, and mineral water.
1927		303,302					[2]		[2]		816,140		1,053,314	Cement. clay (pottery), limestone, and mineral water.
1928	[2]								[2]		590,792		1,609,690	Brick and hollow tile, cement, clay, coal, mineral water.
												7,003 tons	6,327	Pottery clay.
1929	[2]								[2]		413,837		1,407,792	Brick and hollow tile, cement, mineral water, glass sand.
													102,036	Gold.
												199,186 fine ozs.	76,687	Silver.
1930									[2]		398,613		1,065,950	Brick and hollow tile, cement, clay, mineral water, quicksilver, glass sand.
												5,368 tons	3,813	Pottery clay.
1931	[2]								[2]		315,825		973,204	Brick and hollow tile, cement, mineral water, glass sand.
1932	[2]								[2]		231,590		782,403	Brick and hollow tile, cement, clay, mineral water, quicksilver, glass sand.
1933	and tile	268,235							[2]		322,483		641,253	Cement, clay, mineral water, glass sand.
1934	[2]								[2]		408,412		1,326,587	Brick and hollow building tile, cement, pottery clay, mineral water, sandstone, silica (glass sand).
1935		368,028							[2]		274,237		719,351	Cement, clay, copper, lead, mineral water, silica.
												14,245 tons	15,931	Pottery clay.
1936		423,887							[2]		427,731		837,582	Cement, mineral water, quicksilver, glass sand.
1937		497,543							[2]		518,760		851,006	Cement, clay, mineral water, quicksilver, silica.
1938		483,961							[2]		433,644		1,198,680	Cement, clay, mineral water, quicksilver, silica.
1939		695,508	[2]						[2]		320,320		1,190,303	Cement, clay, coal, gems, mineral water, quicksilver, silica.
1940		[2]	[2]						[2]		278,477		1,960,631	Brick and tile, cement, clay, coal, diatomite, mineral water, quicksilver, glass sand.
1941		[2]	[2]						[2]		769,537		2,493,554	Brick and tile, cement, mineral water, natural gas, quicksilver, glass sand.
1942		[2]							[2]		1,153,454		2,913,022	Brick and tile, cement, mineral water, quicksilver, silica (glass sand).
1943		[2]							[2]		1,171,432		3,113,389	Brick and hollow tile, cement, clay (pottery), mineral water, natural gas, quicksilver, silica (glass sand).
1944		[2]							[2]		942,406		2,301,773	Brick and hollow tile, cement, mineral water, natural gas, quicksilver, silica (glass sand).

Table 2. Mineral production of Contra Costa County, 1894-1956.—Continued

Year	Brick		Coal*		Lime		Limestone		Mineral water		Miscellaneous stone[1]	Miscellaneous and unapportioned		
	M	Value	Tons	Value	Barrels	Value	Tons	Value	Gallons	Value	Value	Amount	Value	Substance
1945	------	[2]	------	------	------	------	------	------	[2]	------	687,560	------	1,808,972	Brick and hollow tile, cement, mineral water, natural gas, pumice, quicksilver, silica (glass sand).
1946	------	[2]	------	------	------	------	------	------	[2]	------	669,497	------	2,597,475	Brick, hollow tile, cement, mineral water, natural gas, pumice, quicksilver, silica (glass sand).
												378,734 tons	248,403	Sand.
1947	------	[5]	------	------	------	------	------	------	------	------	509,546	------	647,733	Raw clay, natural gas, pumice.
												372,013 tons	252,229	Sand.
1948	------	[5]	------	------	------	------	------	------	------	------	586,904	------	416,443	Raw clay, natural gas, peat, pumice.
												361,245 tons	158,889	Sand.
1949	------	[5]	------	------	------	------	------	------	------	------	603,310	------	487,774	Clays, natural gas, peat.
												------	349,585	Clay and natural gas.
1950	------	[5]	------	------	------	------	------	------	------	------	710,885	304,608 tons	160,275	Sand.
												183,578 tons	159,819	Sand.
1951	------	[5]	------	------	------	------	------	------	------	------	675,584	------	319,426	Clay, mercury, natural gas.
												179,824 tons	126,501	Sand.
1952	------	[5]	------	------	------	------	------	------	------	------	------	61,888 tons	82,720	Clay.
												------	1,031,188	Natural gas, peat, mercury, stone.
												84,242 tons	55,771	Sand.
1953	------	[5]	------	------	------	------	------	------	------	------	1,236,269	------	332,981	Clay, peat, natural gas.
												516,912 tons	507,978	Sand.
1954	------	[5]	------	------	------	------	------	------	------	------	1,195,252	------	1,003,696	Clay, mercury, natural gas, peat, potassium salts, by-product sulfur.
												117,649 tons	126,555	Sand.
1955	------	[5]	------	------	------	------	------	------	------	------	2,153,561	------	1,615,596	Clay, natural gas, peat, by-product sulfur.
												196,809 tons	221,841	Sand.
1956	------	[5]	------	------	------	------	------	------	------	------	3,211,808	------	1,751,229	Clay, natural gas, potassium salts, by-product sulfur, hydrogen sulfide, and peat.
Totals	388,669	$7,069,768	368,082	$978,925	253,503	$214,392	294,938	$391,922	3,286,545	$135,782	$30,673,690	------	$59,176,552	

Grand total value, $98,641,031

[1] Includes crushed rock, rubble, riprap, sand. After 1946 sand is separated.

[2] See under "Unapportioned."

[3] Estimated.

[4] The Ryne mine on Mt. Diablo was active in 1875-1877 (inc.) and produced as high

[5] Included with heavy clay products. Value not added to county total.

[6] Asphalt recovered at oil refineries from oil produced outside the county.

* Coal mining began in the Mount Diablo section of Contra Costa County at least as early as 1861, but there are no segregated county figures available earlier than those here shown. For 1867-1882 (inc.) there are records that indicate for the

actinolite schist, has an assemblage of minerals that includes, besides anthophyllite and tremolite asbestos, hornblende, glaucophane, chlorite, talc, and diallage. W. C. Blaisdale, writing in 1902, described the locality in these words:

"One large detached rock mass, some 20 feet long by six in thickness and 5 in width, illustrates the occurrence of the mineral in situ. This formed an exceedingly compact rock, composed for the most part of the relatively large crystals of the blue hornblende arranged without any common orientation and associated with garnet, chlorite, actinolite, titanite, and albite. The chlorite and actinolite were frequently localized in certain portions of the rock . . . the other minerals were more generally distributed through the entire mass. . . .

"Between the beds of dark-colored serpentine and schist here found, a thin layer of light-colored fibrous mineral was noted. . . . The pure mineral occurs in masses of fibrous crystals pure white to light gray-green color which show a pronounced schistose structure. This is easily crumbled into fine needle-like crystals. . . . The composition of this mineral is clearly that of tremolite.

"Serpentinized anthophyllite occurs in groups of massive boulders, often rounded but more commonly angular, which outcrop at several points in the locality, often projecting to the height of 20 feet above the prevailing level and suggesting the character of intrusions. The rock is exceedingly tough and compact, and does not fissure readily. The outer surfaces are an ashy gray color but the freshly exposed portions present yellow-green cleavage planes or curved surfaces of a light brownish-yellow."

Chromite

In the Coast Ranges of California, chromite ($FeCr_2O_4$) is associated with basic intrusive rocks of the Franciscan formation, or with their alteration products, particularly serpentine. Chromite is found as stringers and lenses or as disseminated grains in the host rock. Though some claims have been located in the Mt. Diablo area, there is no record of chromite production.

Clay

As early as 1868, clay for fire-brick, crucibles, and stoneware was obtained from the Black Diamond coal mine at Nortonville and Marsh's Ranch. In the period 1868-86 the Albion Pottery Company was making pottery at Antioch from clay mined at the Brentwood coal mine. To date at least a dozen organizations have mined clay in the county.

Several plants that process clay mined in other counties are in Contra Costa County. Gladding, McBean and Company produces refractories from Ione fire clay at their Pittsburg plant, one of the largest of its kind in the state. The California Art Tile Corporation, the Technical Porcelain and Chinaware Company, and the American Radiator and Standard Sanitary Manufacturing Company all manufacture ceramic products from materials obtained outside the county. Although high grade clay is not abundant, a substantial brick industry derives its raw materials from the clay shales of the county. At present, two brick plants are operating: one at Port Costa and one at Point Richmond.

Port Costa Brick Works. Location: sec. 10, T. 2 N., R. 3 W. (projected), on Carquinez Strait, three-quarters of a mile east of Port Costa. Ownership: Port Costa Brick Works, 401 Berry Street, San Francisco; plant superintendent is Lawrence Mossina.

The Port Costa plant has made common brick from local clay shales almost continuously since its establishment in 1905. The brick have heretofore been fired in a Hoffman continuous coal-burning kiln, supple-

mented during the peak summer seasons by four field kilns. In August 1957 a new 265-foot tunnel kiln with supporting dryers and product storage area was installed.

Clay shale is quarried about a quarter of a mile from the plant. The shale is from the upper part of the Upper Cretaceous Chico formation, which here strikes northwest and dips 50° SW., though the attitudes are not constant, owing to numerous local folds. At one quarry, the beds mined have been exposed beneath a 3- to 15-foot overburden of brown soil. The quarry face shows thinly laminated, yellowish-brown clay shale alternating with thin-bedded, yellowish brown sandstone. Although the shale beds are at maximum only about half as thick as the sandstone beds (the clay being about 6 inches, the sandstone a foot), the color of all of them changed with depth to a bluish gray. The shale beds, on weathering, produce forms that resemble concretions.

The clay shale is mined by a diesel-powered shovel at a rate varying from 150 to 300 tons per day, depending upon seasonal demand. Blasting is required only occasionally.

The shale is trucked to the plant, where it is fed into a dry grinding pan to be mixed with a grog of broken brick, then sent over an 8-mesh screen. The clay and grog that does not fall through the screen is considered too coarse for use, and is returned to the circuit. The material that passes through the screen remains in the plant circuit, and is next blended with Lincoln clay, then sent to a pugmill where it is mixed with water to make a stiff mud. The mix is de-aired, then extruded through a rectangular die onto a conveyor belt. The mixture, now essentially green brick, progresses along the conveyor belt as a long ribbon of brown clay until it is conveyed into an automatic wire cutting machine that slices the ribbon into neat units of eight brick.

After cutting, the brick shapes are placed on kiln cars that are sent through a series of tunnels, to emerge from the last as a kiln car loaded with fired red brick that is ready for cooling and marketing. The green brick goes to a conditioning tunnel, where it is kept at a temperature of 70° to 90° F.; then to waste air drying tunnel maintained at 95° to 150° F. The last, and most important tunnel is the firing tunnel itself, a continuous gas-fired kiln some 265 feet long that holds 26 cars. Here the temperature will reach a maximum of 1840° F., as measured by recording optical pyrometers. The bricks are left in the dryer 2 days, and in the firing kiln $2\frac{1}{2}$ days.

Production is 90,000 to 120,000 brick per day depending upon the season of the year. Peak demand is during the summer when the building industry is most active. The principal products are common red brick; jumbo brick ($3''$ by $3\frac{1}{2}''$ by $11\frac{1}{2}''$); and norman brick ($3''$ by $2\frac{1}{2}''$ by $11\frac{1}{2}''$).

The quarry and most of the plant is on a 5-day week schedule. About 60 men are employed (May 1958). Sale of the brick is through distributors located at key points in the Bay Area and Central Valley. All shipments are made by company operated motor trucks.

United Materials and Richmond Pressed Brick Company. Location: sec. 23, T. 1 N., R. 5 W., at Point Richmond on San Francisco Bay, immediately north of the natural gas storage tank of the Pacific Gas and Electric Company. Ownership: United Materials and Richmond Pressed Brick Company, Ltd., Box 7, Point Richmond.

This plant was established in 1907 by the Los Angeles Pressed Brick Company. It became an independent operation in 1921 under the name, Richmond Pressed Brick Company; in 1930 the present name was adopted. The company controls about 40 acres of land at Point Richmond. At present 50 men are employed at the plant, producing 40,000 fire bricks per day.

The principal raw material used for brick making is blue clay shale quarried from the Franciscan formation (Upper Jurassic?) near the plant. Large reserves of this material are available on the property. Since this clay shale is hard and non-plastic, it is necessary to blend it with high grade clay to insure strong binding upon extrusion. High grade clay from Lincoln, Placer County, and Ione, Amador County, constitutes about 30 percent of the materials used in the bricks.

A Caterpillar bulldozer digs the shale and pushes it within reach of an overhead clamshell crane, which feeds it to the crushing and grinding machinery; the same crane also unloads clay from railroad gondola cars. The raw materials, including a grog of broken brick and a small percentage of barium carbonate to control efflorescence in the finished product, are pulverized in two dry-pan grinders and passed through three 10- to 14-mesh screens. The ground clay-mix is conveyed to elevated storage bins of 2000-ton capacity.

The clay-mix is then drawn into a pug mill where water is added. The wet clay passes to the auger where it is compressed, forced into a de-airing chamber and through an extrusion head as a ribbon of stiff mud. It is cut into brick by an automatic wire cutter and the bricks are loaded onto the kiln cars for drying and firing.

Drying is done prior to firing with waste heat from the kiln in a twin tunnel dryer 100 feet long. Firing is done in a $5\frac{1}{2}$ by 245-foot, gas-fired Minton tunnel kiln equipped with a hydraulic car pusher and automatic temperature control. It operates on a 3-hour car schedule and residence in the kiln is $3\frac{1}{2}$ days. Six beehive kilns with a capacity of 100,000 bricks are maintained in standby condition. Firing here is done under pyrometric and cone (04) control. Temperatures of 1900° Fahrenheit and 2100° Fahrenheit are attained in the production of red and buff bricks, respectively.

Only face brick is made at this plant. Conventional face brick made here includes: Richmond red wire-cut, red ruffle, rug face, standard, repressed paving brick, buff, and buff rug. Six types of Roman-size face brick, and three types of Norman-size face brick are also made. Miscellaneous face bricks made are: split recessed paver brick and brails brick. Acid brick for the chemical industry as well as brick blocks and fittings for through-all construction (6-8 x $11\frac{1}{2}$ x $3\frac{1}{2}$) are now included in the list of products. Special type, easily damaged bricks are individually wrapped in paper when removed from the kiln. Almost all brick produced here is shipped by truck.

Coal

The industrial development of the San Francisco Bay area in the latter part of the nineteenth century is closely related to the discovery and mining of sub-bituminous coal in Contra Costa County. The mines were active from 1861 to 1902. The mine workings which started at or near the surface, were extended continually to greater depths

along the dip of the coal beds. Consequently the cost of production increased continually and when it reached the economic limit the mines were shut down.

Other factors limiting the life of mining in the area was the character of the coal itself, competition with better grades of imported coal and the increased discovery and use of petroleum. However, certain developments in the chemical treatment of coal and the possibility of gasification or its use as a source of electrical energy have periodically revived interest in the coal deposits in California.

History. Historians are not in agreement on the date of the discovery of coal in Contra Costa County. Bancroft (1890) states that coal was discovered there in 1852, that the deposits were worked in a small way in 1855, and that by 1859 these mines supplied an appreciable quantity of coal to the San Francisco market.

A more detailed account of events culminating in the location of the coal mines was presented by J. T. Cruikshank (1876) in a county Centennial paper published in the Contra Costa County Gazette. Since this presentation was made by one of the participants in the early-day activities, it is reproduced below to supply a background for the mining events which ensued during the 43 years between the birth and demise of the industry.

"In 1859, at Horse Haven, six miles south of Antioch, William C. Israel, in cleaning out a spring on his land, discovered a vein of coal. In connection with his father and brother George, he opened the vein for a short distance; but, not having capital to work it, they disposed of their interest to James T. Watkins and — Noyes, who, either from want of knowledge or capital, failed in opening the vein so as to make the working of it successful. They abandoned the mine in 1861. It has not since been opened.

On the 22nd of December, 1859, at a distance of three and one-half miles west of Horse Haven, Francis Somers and James T. Cruikshank discovered the vein of coal which has since become so well known as the Black Diamond vein. Somers, Cruikshank, and their associates, H. S. Hawxhurst and Samuel Adams, located the lands which were afterwards known as the Manhattan and Eureka coal mines.

George Hawxhurst, George H. P. Henderson, and Wm. Henderson, in company with Francis Somers, opened the cropping of the same vein, on what was afterwards known as the Black Diamond and Cumberland mines. But, believing that the expense of making roads was beyond their means, they made no attempt to secure title. The Black Diamond mine was shortly after located by Noah Norton, and the Cumberland mine went into the hands of Frank Such and others. These lands, with others adjoining have since become noted as the Black Diamond coal mines.

The Pittsburg mine, east of the Eureka and towards Horse Haven, was located by George H. P. Henderson, who entered into a contract with Ezra Clark to open the mine, in the opening of which the vein of coal known as the Clark vein was discovered.

The Central coal mine, east of the Pittsburg, was located by John E. Wright. The year following Wm. B. Stewart became connected with it and still remains so.

The Union mine, north of the Manhattan, was located by George Hawxhurst.

The Independent mine, north of the Eureka, was purchased from Major Richard Charnoch by Greenhood and Neubauer.

The Manhattan, Union, Eureka and Independent, comprise the mines forming the basin in which the town of Somersville is situated, and from which there is a railroad for the transportation of coal to Pittsburg Landing, on the San Joaquin.

The Cumberland, Black Diamond, Mt. Hope and other lands, comprise the basin of the town of Nortonville, and from which also a railroad exists for the transportation of coal to Black Diamond Landing, at the head of Suisun bay.

The Empire is six miles south of Antioch, and within three-fourths of a mile of the first opening made on the coal veins of the county by the Israels. The mine

is owned by George Hawxhurst and John C. Rouse. Openings on the veins from that mine to the Brentwood coal company's works on Marsh's grant have been made. . . .

The coal mining interest is becoming rapidly one of the most important ones of the county. It has already built up four towns, viz: Somersville, Nortonville, Black Diamond and Pittsburg Landings, and added greatly towards the progress of Antioch, which place was settled upon in 1849 and 1850 by Parson W. W. Smith, George W. Kimball and J. C. McMaster.

General Geology. The coal beds crop out in the northern foothills of Mt. Diablo about 5 miles northeast of the principal peak of the mountain. The beds can be traced in an intermittent arclike pattern from the northwestern part of T. 1 N., R. 1 E., to the southeastern part of T. 1 N., R. 2 E., a distance of about 10 miles. The most productive mines extended along a 4-mile strip at the west end of the belt.

The coal beds occur in the Domengine formation of middle Eocene age and are associated with friable, heavy-bedded, white, high-silica sandstone as well as impure coaly beds which grade laterally into thin-bedded shale. Many geologists believe that this Mt. Diablo sedimentary section of rocks containing the coal measures is the western equivalent of the Ione coal-bearing formation found in the foothills of the Sierra Nevada. If such is the case, the Domengine formation merges with the Ione formation far below the surface of alluvium in the Great Valley.

The Eocene sandstones and shales extend from Concord to Byron, a distance of about 21 miles. The strike of the beds ranges from west, at the west end of the belt, to north 40° west at the east end of the belt. The dip increases from 12° northeast to 40° north, proceeding along the strike from east to west, both at the surface and at depths reached in the mines. These steep dips are a disadvantage in mining because they increase the cost of production at a rapid rate. The principal coal beds, the Clark and the Black Diamond, crop out in the area. They have been classed as sub-bituminous by the U. S. Bureau of Mines. Table 3 presents typical analyses of coal from the Clark and Black Diamond beds. In general the surface coal is weathered. The quality of the coal improves down the dip to a depth of about 200 feet.

Table 3. Analyses of coal from Clark and Black Diamond beds.

	Clark bed	*Black Diamond bed*
Specific gravity	1.3539	1.4150
Moisture	11.64	13.015
Volatile matter	47.365	42.15
Fixed carbon	34.43	35.235
Ash	6.645	10.600

The Clark bed is $1\frac{1}{2}$ to $4\frac{1}{2}$ feet thick, and is generally free of interstratified undesirable material. However, at the thicker portions of the bed an overlying clay bed, as much as $2\frac{1}{2}$ feet thick, caused some mining difficulties. Workings on the Clark bed extended along its entire length, some workings reaching a depth of 710 feet.

The Black Diamond bed is by far the largest deposit in the field. It is 375 feet stratigraphically below the Clark bed and ranges from 6 to 18 feet thick including considerable interstratified clay, slate, and impure slaty coal. In general the best coal from the Black Diamond bed is superior to the coal from the Clark bed, but it was more expensive to mine as more timbering was required to support the workings.

Thinner coal seams occur between the Clark and the Black Diamond beds throughout the district. These seams showed considerable variation in thickness along the strike, and in some mines became thick enough to afford profitable mining. One intermediate seam was termed the "Little" bed and was worked extensively in the Union and Eureka mines.

The coal beds were frequently offset by faults, according to Goodyear (1877). Over the $2\frac{1}{2}$-miles stretch of most profitable mining near Somersville, at least seven faults of considerable magnitude were known. Throws ranged from 10 to 150 feet. Outside this area, dislocations were of even greater magnitude.

The underground workings of the coal mines in the county are inaccessible, except parts of the old Black Diamond mine (Nortonville) and parts of the Pittsburg mine at Somersville. Some openings at these mines were maintained by the Roberts Sand Company and the Pittsburg Sand Company for mining clay-free foundry sand and glass sand, respectively.

Mining developments at the two principal mines are summarized below. A summary of developments at the other mines and prospects will be found in the tabulated list at the end of this report. A detailed description of the Mt. Diablo coal field was prepared by Goodyear (1877), and much of the data is taken from his report.

Production Data. The first recorded coal production came from the Black Diamond mine in 1861. The Union mine reported production in 1865; the Pittsburg, Eureka and Independent in 1866; and the Central in 1867. Production for the entire Mt. Diablo coal field increased annually and a production peak was reached in 1874 when 215,352 long tons were reported. From 1868 to 1886 about 2,500,000 long tons of coal were produced—an average yearly production of more than 160,000 long tons. At one time about 1,000 miners were employed in the district.

After 1874 production declined intermittently as unprofitable operations forced closing of the smaller mines. The Black Diamond mine closed in 1885 and the Pittsburg mine was the principal producer after that date. A moderate revival of activity was enjoyed during the nineties but production again declined sharply after the turn of the century and ceased entirely in 1902. Competition from petroleum products and imported high-rank coal forced cessation of coal output from the Mt. Diablo field. Although production statistics are incomplete, indications are that about 3,500,000 long tons of coal have been taken from the district.

The product of the mines was transported from Black Diamond (Pittsburg) and Antioch by steamer to the principal markets at San Francisco, Sacramento and Stockton. Considerable quantities of coal were consumed also as a source of power for hoisting and pumping at the mines, and for the locomotives on the mine railroads. Some sales of coal were made locally to the townsfolk of Nortonville, Somersville, Black Diamond, and Antioch.

Mining Methods. An inclined room and pillar method of stoping was employed by the coal mines of the district. The method described in

a report on the Star mine (Crawford, 1894) was applicable to all mines in the area and is quoted below:

"No powder is used to mine the coal, the pick being sufficient. In driving the gangway, where sandstone is encountered, No. 2 giant powder is employed, and two men working together drive about 6 ft. per day. There is as yet no necessity of artificial ventilation in the mine, as quite a draft exists through the old workings. Several small faults were cut through; the largest "jump" in the lower workings was $2\frac{1}{2}$ feet, while on the upper gangway it was 9 ft. The mine makes about 100 cu. ft. of water per hour, which is hoisted out of the sump by a 300-gallon wooden tank, set on regular trucks. It is supplied with a valve in the bottom, so as to fill it as it sinks into the water of the sump. The hoisting engineer has a cylinder 10-in. by 12-in., and a winding drum $6\frac{1}{2}$ ft. in diameter. Hoisting is done with a velocity of about 8 ft. per second. The mine employs about 40 men at present, but the number fluctuates constantly. The coal is shipped as it comes out of the mine, no screening being attempted.

"In all the mines of this neighborhood the coal is mined in rooms 30 ft. wide and as long as the distance may be to the next gangway (a lift, generally 400 ft.). The gangway is driven somewhat below the coal, in such a way that the bottom of the vein lies about 5 ft. above the floor of the gangway. An opening 4 ft. wide is made in the coal, which gradually widens to the width of the room—30 ft. The coal is run down into the gangway through a chute made of boards and lined with sheetiron; it is 3 ft. wide and 6 to 8 in. deep. As the miner works his way up in his room he adds length after length to his chute, until he reaches the next gangway above. He does nearly all work on his knees or lying on his side. As soon as he has sufficient coal picked loose to make it inconvenient he shovels it into the end of the chute; here it is taken charge of by a boy (called a nobber), who works it down the chute. At the lower end a board is set across the chute to prevent the coal from wasting until a car is pushed under to receive it. The cars are hauled by mules or pushed by men along the gangway to the slope, and there hoisted. Whale oil is used to keep the chutes slick, and about one gallon is reckoned for that purpose per miner per day.

"Props of redwood with a short cap are put in as soon as the coal is taken out. An average of one prop for every square yard of space is required; in addition to this some extra timbers are put on each side of the chute. In bad ground cribs are used, built up of short posts and filled with stone (cogs). The gangways and tunnels

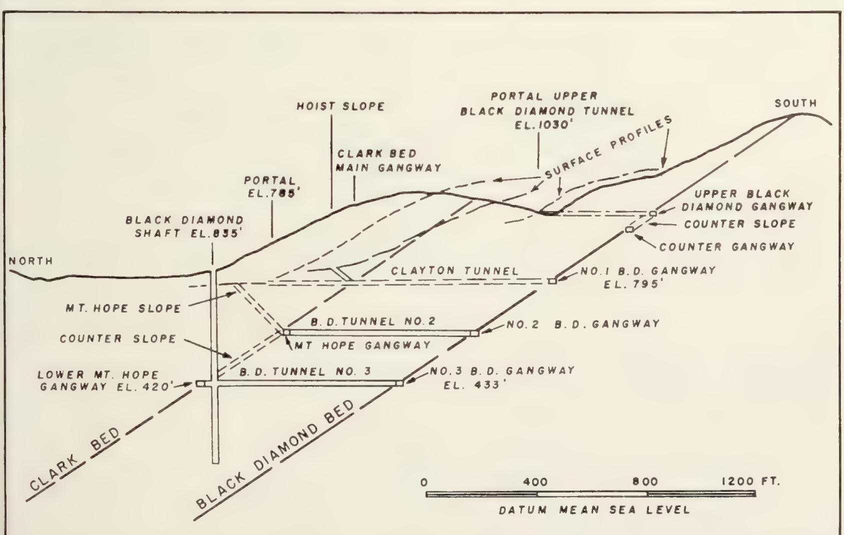

FIGURE 1. Section through Black Diamond coal mine. (Calif. Journal of Mines and Geology, vol. 51, no. 4, p. 344).

have a 1 per cent grade toward the foot of the hoisting slope in order that the water may drain from the whole mine into the sump and loaded cars run easily.

Black Diamond Mine (Union, Manhattan, Peacock, Nortonville, Mt. Hope, Cumberland). Location: About 4 miles south of the center of Pittsburg on the Railroad Avenue-Nortonville road; in the SE$\frac{1}{4}$ of sec. 5 and parts of sec. 4, 8, 9, T. 1 N., R. 1 E., M. D. Ownership: Southport Land and Commercial Company, 220 Montgomery Street, San Francisco, California.

The Black Diamond Coal Mining Company was incorporated in 1861 with a capital of $5,000,000 and the town of Nortonville grew up around the headquarters of the mine. Two other mines near Nortonville, the Mt. Hope and the Cumberland, became part of the Black Diamond holdings. During the early days, the Black Diamond coal was hauled by mules on a team road which ran down Kirker Creek to the shipping point at New York Landing. The latter name was later changed to Black Diamond and finally to Pittsburg in 1909. A railroad was built over this route in the middle 1860's. Extensive development of the mine followed and production continued to mount until 1874. In that year the Black Diamond workings reached the peak of their production—117,804 long tons.

During the next ten years, coal production declined as the mine was beset with numerous difficulties: first, an underground explosion which claimed 11 lives; then, strike against the reduction of wages; then, flooding of the workings by heavy surface rains; next, the operational difficulties and higher costs occasioned by working the mines at increasingly lower levels; finally, competition with better grades of coal imported from outside the state. Eventually, in 1885, in the face of overproduction and a slow market, the Black Diamond Company removed their mine and railroad equipment and permanently closed the mine. Total production from 1861 to 1885 was 1,402,215 long tons of coal.

It was reopened in 1905 to supply coal to a briquetting plant at Los Medanos. Shortly thereafter, the plant burned and the mine was closed.

A few hundred tons of coal per year were produced by caretakers at the mine in the periods 1915-17. About 1925 several men were employed in retimbering and reopening the Clayton tunnel, a south-trending crosscut which intersects the three principal coal beds in the mine. A small amount of coal was produced in 1928.

In 1939-40 a small group of lessors worked the mine and mined a small tonnage of coal. At that time it was hoped that the coal could be used as a source of electric power.

During the 20-year period from 1922 to 1945, the mine intermittently produced high-silica sand for use in the foundry of the Columbia Steel Company at Pittsburg (see sand section in this report).

In 1958 a new lease was granted to the Silver Sand Company which planned to resume sand production from the mine.

Pittsburg Mine (Eureka, Independent, Somersville). Location: About 6 miles southeast of the center of Antioch on the Somersville-Markeley Canyon road; in the SE $\frac{1}{4}$ of sec. 4, T. 1 N., R. 1 E., M. D., Ownership: Southern Pacific Company, 65 Market St., San Francisco.

The Pittsburg mine was located in 1860 and the Clark bed was discovered during the period of exploration at this property. The com-

pany was incorporated as the Pittsburg Mining Company on October 1, 1861. Although coal production was made here at an early date no adequate production records can be found. The Pittsburg Railroad began hauling coal from Somersville in 1866 and the first recorded production was made in that year, totaling 9599 long tons. Production figures for all mines using the facilities of the Pittsburg Railroad between 1866 and 1887 are presented by Goodyear (1887). The Pittsburg mine produced coal until 1902. Total production is estimated from incomplete data to be over 1,000,000 long tons.

Diatomite

Beds of good grade freshwater diatomite occur in Tertiary sedimentary rocks of the Monterey group especially in the vicinity of Pinole. Massive beds crop out in a narrow band extending from Pinole westward for 1½ miles and from Highway 40 northward for about 1000 feet. The beds dip northward about 30° and have been mapped as Tice shale (Weaver 1949). They are overlain in this area by the Pinole tuff which also dips northward at an angle of 30°.

The diatomite is a lightweight, irregularly fractured, chalky, grayish-white rock which weathers to a dirty-gray color. The genus *Melosira* is present in samples of diatomite from the upper part of the section but is absent from the underlying material in which discoid types are abundant. Small cuts are found at numerous points and evidence of a more extensive quarrying operation can be seen on the hilltop in section 22. As far as we know the diatomite was used only as fill material.

A thick bed of diatomite is exposed in a road cut on the south side of Highway 40, 1½ miles west of Pinole. It appears to be at least 100 feet thick and overlies a section of alternating beds of diatomite and sandstone ranging from a few inches to 2 feet in thickness. The sandstone beds strike eastward and dip 80° north. All these beds have been mapped as Claremont shale of the Monterey group of middle Miocene age (Weaver 1949).

Gold, Silver, Copper and Lead

Gold associated with copper sulfides (chalcocite and chalcopyrite) was discovered in the Mitchell Canyon drainage area on the north slopes of Mt. Diablo about 1863. A feverish period of prospecting and exploration in the vicinity of Mt. Zion, Black Point and Eagle Point followed but no large ore body was ever discovered.

An interesting account of this exploration activity is reproduced below from a publication of that period (Mining and Scientific Press 1865).

> Near the peak of this summit, and on the westerly slope, we have the Summit of Zion mine, and on the easterly slope is located the Mount Zion Copper Company . . . In passing through the Mitchell Canyon, upon either hand, but chiefly upon its northerly acclivity, may be noticed numerous other companies working for copper. Although very fine specimens and bunches of sulphurets, together with some native copper, are found, no very extensive operations have yet been carried on there, for the reason that no well-defined veins have yet been discovered; the bunches of ore having the appearance of being isolated deposits. This canyon and Mount Zion, already described, contain the chief copper deposits yet found in and about Mount Diablo.

Ascending to the head of this canyon, we come to the mining ground of what is known as the Open Sesame Mining Company. This company was incorporated August 5, 1863, and was consolidated from thirteen other companies. The consolidated company now owns what is considered to be nine different ledges, named as follows: Cascade, Black, Henriquita, Carmel, Santa Domingo, Herman, Cortez, San Pedro, La Verdad, La Feliz, and White Diamond; they also own the first extensions of the Cascade, Black, Henriquita, and Cortez.

The three principal mines of the company are the White Diamond, the La Feliz and the San Pedro. These mines are located on the right hand side of Bagley canyon, just before reaching its source. They are located one above the other in the order named, and are each plainly exposed to view by the wearing away by the waters of this canyon.

White Diamond Ledge is the lowest in the series of supposed gold and silver ledges, which in geological position overlie the copper deposits of Mitchell Canyon, and, if we are not mistaken in our hasty examination, of Mount Zion, also . . . The trend or direction is nearly north and south, and the dip is to the westward, at an angle of about forty-five degrees. But little or nothing has yet been done towards developing this vein, which has merely been opened. It is massive, some eight feet thick on the surface. According to the superintendent's last report to the company, 113 pounds of this rock was sampled and assayed by Riehn, Hemme & Co., of this city, showing a yield of $119 to the ton, in gold and silver.

La Feliz ledge . . . although it does not show as distinctly upon the surface as the White Diamond, is nevertheless quite well defined. It contains 9,800 feet of ground, and is about 150 yards in vertical height above the White Diamond, to which it is parallel. The first tunnel commenced upon this ledge has been continued a distance of 140 feet. The walls of the vein were distinctly defined from the mouth of the tunnel some fifteen feet, at which point a fault was encountered, where the vein matter appeared to have been considerably disturbed. From that point onward the vein walls are quite well defined to the extreme end of the tunnel. Numerous assays of rock from this mine have been made, which have generally assayed about $45 to the ton; some have gone as high as $100, and in one instance an assay, fairly assorted from some sixty pounds of ore taken from a "pocket," went as high as $291 to a ton, (incorrectly printed at the time in the superintendent's report at $201 to the ton.) One lot of two tons, taken as it came from the mine, was brought to this city and worked, a little over a year ago, which yielded at the rate of $26 to the ton.

Going still further up the mountain we come to the San Pedro Ledge, upon which the Open Sesame Company hold 9,800 feet. This vein is equally well defined with those already noticed, and exhibits the heaviest outcrop of any yet opened, measuring about thirty feet in width at the surface. The company commenced work by clearing off an esplanade in front of the tunnel. After which a tunnel was run in about fifty feet, keeping the wall rock well defined upon the left. From this point a drift was run to the right across the vein and thence downwards, nearly in a right line, twenty-two feet, at which point the vein matter was very much concentrated, exhibiting an almost uniform mass of sulphurets, which entirely covered the bottom of the shaft seven by eight feet. Some thirty tons of first-class ore was taken out in sinking this shaft, besides a large quantity of second and third class, that was thrown into the dump. This shaft was full of water at the time of our visit and of course we could not examine it; but we have gathered the particulars from conversation with one of the proprietors and the superintendent, Felix A. Mathews, also a large stockholder.

Since writing the above, O. C. Coffin, President of the Open Sesame Company, has handed us the following report of working and assays, which have been made the past week in this city, and which he has desired us to publish for the benefit and information of the shareholders in the company:

> "Working result by Kimball and Murphy, of the European Metallurgical Works, on Bryant Street:
>
> "A lot of 1,700 pounds of rock from the La Feliz vein yielded at the rate of $2.87 in gold and $2.25 in silver; total, $5.12 per ton.
>
> "A lot of 1,900 pounds from the San Pedro vein yielded at the rate of $4.60 in gold and $2.55 in silver; total, $7.15 per ton. In each of the above cases the entire lot mentioned was worked. . . . .
>
> "One hundred pounds of ore from the San Pedro was worked raw, without producing any result."

In addition to the above working test, Capt. Coffin also requests us to publish the following assays:

By G. E. Moore—the San Pedro rock was returned as yielding, per ton, $2.41 in gold, with a trace only of silver.

The same assayer returns for the La Feliz—Mere traces of gold and silver, of no practical value.

Riehn, Hemme & Co. returned as an assay of ore from the San Pedro—$3.15 in silver, with a mere trace of gold.

With regard to the difference noticed between the assays given in the former portion of this article and taken from the superintendent's published reports of 1863, and those obtained, in part from the same parties, during the past week, and furnished us by Capt. Coffin, we have merely to say, in lack of positive knowledge, that the former might have been taken from near the croppings of the mines, which are often found much richer than the ore a short distance below. At all events, this discrepancy goes to show the necessity of moving with the utmost care and circumspection, especially in the beginning of all mining operations.

In 1907, John Neate and Charles Olaine prospected in the area and rediscovered several veins carrying gold and copper. They reported one lode from 80 to 100 feet wide from which samples assaying $4 to $26 in gold and 2½ percent copper were obtained.

No recovery of gold or silver has been reported from ore mined in Contra Costa County. The county, however, has been a metallurgical center for many years and the gold production recorded in 1930 was from "left over residues and smelter materials of abandoned reduction plants." The ore processed in these plants was mined elsewhere (Heikes 1933).

The production of copper is recorded in the county mineral production table for the years 1902, 1918, and 1935. This output was originally attributed to the Mt. Zion prospects. Subsequent investigation, however, has disclosed it was recovered at local smelters from ore mined outside the county.

Selby Lead Smelter. Contra Costa County is primarily an industrial county, ranking second among all counties in the eleven western states in value of manufactured products. The industrial section of the county is mainly along tidewater from Richmond to Antioch where industrial fuel, water, and power are abundant.

An extensive mineral processing industry is centered in this area. Petroleum refining is the leading industry; refineries are at Richmond, Oleum, Martinez, and Associated. The only lead smelter on the Pacific Coast is operated at Selby by the American Smelting and Refining Company. Refractories are manufactured at Pittsburg from California clays. At Richmond, mineral wool is produced from copper slag; pyrite is roasted and the sulfur dioxide gas is recovered for the manufacture of sulfuric acid.

The Selby lead smelter is located at Selby, at tidewater north of U. S. Highway 40, about 2 miles west of the Carquinez Bridge. It is owned by American Smelting and Refining Company, 405 Montgomery Street, San Francisco.

The Selby smelter was established in 1883 by Tom Selby, a San Francisco shot-maker, who had expanded into the business of smelting western lead ores. His first blast furnace, which treated a half a ton of ore, was blown-in in 1885. From this early beginning, the smelter has been enlarged to its present capacity of 20,000 tons of charges per month, and receives shipments of ore and concentrates from all over

the world. It smelts gold-silver and lead ores and concentrates and refines impure dredge gold, gold precipitates from cyanide mills, and scrap gold obtained from precious metal dealers. The lead sulfide concentrates receive a preliminary roasting to eliminate the sulfur and convert them into oxides. The oxides mixed with gold ores are reduced in a blast furnace to relatively pure metallic lead.

Ores from the western states, South America, Australia, and the Philippines are received by motor truck, rail, or water. They are unloaded into bins, trucked to the scale-house for weighing and sampling, and then stock piled. Most of the shipments are in the form of concentrates from gravity or flotation mills, but some shipments of high-grade ore from small mines are also received. The shipments range in size from a truckload containing 2 to 5 tons of ore, through a carload containing 30 to 50 tons of ore or concentrates, to a shipload of 10,000 tons. The purchase of small lots of ore and immediate payment for them has been helpful to the small producer.

The concentrates received at the smelter are usually too fine for charging directly to the furnace. It is therefore necessary to combine or agglomerate the particles into fragments ranging from 1 inch to 6 inches in size. This is done in a Dwight-Lloyd sintering machine. Prior to sintering, the stock pile concentrate is first delivered to one of 12 mixing bins. Here water is added and the resulting mass is dropped through pan feeders to a proportioning belt leading to the machines. In sintering, the charge on the sinter pallet is given a preliminary flash firing to ignite the mass and is then downdraft blast-fired to burn off the sulfur as sulfur dioxide gas. The sulfur content of the sinter charge is reduced from about 12 to 5 percent in the first pass through the Dwight-Lloyd machine. The sinter cake is discharged in large fragments, again crushed to a fine particle size, and sent through a second Dwight-Lloyd machine where the sulfur content is reduced to about 1.8 percent. The sinter fragments discharged from the second machine are ready for smelting. They are delivered to a furnace charging car, coke and scrap iron are added, and the car is elevated vertically to the charging floor of the blast furnace about 50 feet above ground level.

In the blast furnace the charge is heated to the point where a number of reactions take place. The metallic lead trickles downward through the furnace and is collected in the fore-hearth from which it is periodically withdrawn in a fiery red stream.

Gold-silver and lead ores and concentrates usually contain small quantities of numerous other metals which are reduced with the lead. Copper, arsenic, antimony, tin, and bismuth are therefore present as impurities in the unrefined lead and may constitute 10 percent of the total. The lead bullion from the blast furnace is received in iron pots of approximately 4-ton capacity and transferred to a drossing kettle. Here the metal is held at a low temperature and agitated with air to oxidize part of the impurities which float to the surface and are skimmed off. This skimmed product, dross, consists primarily of lead-copper arsenides and antimonides.

The dross is treated in a reverberatory furnace which produces lead bullion, a high-copper speiss, and a low-copper matte. The lead bullion is returned to the drossing kettles. The high-copper speiss which contains approximately 60 percent copper, and the matte which contains

12 to 20 percent copper, are shipped to the company's copper refinery at Tacoma, Washington. The drossed lead is pumped to a second kettle and allowed to cool to the freezing point; it is reheated and the remaining copper taken off as a dross. The resulting bullion is cast into 5-ton blocks for transfer to the refinery. The metals of iron, calcium, zinc, aluminum, and magnesium which were present as gangue in the original ore, remain oxidized and combine with the silica to form slag, which is tapped through the fore-hearth to slag cars and trammed to the slag dump. Zinc is an undesirable metal in ores shipped to a lead smelter since it requires fluxing and is usually penalized if present in quantities above a specified minimum percentage.

A portion of the copper in the ore combines with the iron and the arsenic in the blast furnace to form a copper-iron speiss containing 10-12 percent copper. This product is separated in the fore-hearth of the furnace and is also shipped to the copper refinery at Tacoma.

Lead bullion from the smelting department still contains gold and silver, and impurities such as arsenic, antimony, tin, and bismuth. These impurities, especially antimony, make the lead hard. The first step in the refining process consists of removing the antimony and tin by oxidation and is therefore known as softening the lead. Softening is done in a 200-ton reverberatory furnace. The antimony, tin, and some lead oxide, rise to the surface and are skimmed off. When the lead is completely softened, it is ready for desilverizing, and is pumped to desilverizing kettles of 200-ton capacity.

Silver and gold are recovered from the lead bullion by the Parkes process. Zinc, which has a strong affinity for silver and gold, is added to the liquid lead bullion and mechanically "stirred in." The zinc, silver, and gold form compounds which have high melting points and lower specific gravities than the lead bullion. Consequently, the zinc containing gold and silver floats to the top of the kettle as a crust and is removed by skimming. This zinc crust is placed in a press to remove most of the entrained lead and is then sent to the silver refinery. Here the zinc crusts are placed in a retort and the zinc is recovered by distillation. The residue metal consists of a high grade lead bullion which is treated in a cupelling furnace to remove the lead. The lead is oxidized to litharge and drained off, leaving a doré bullion of gold and silver which is cast into anodes. These anodes are treated electrolytically for the separation or parting of gold and silver by the Moebius process. Silver is recovered at the cathode in the form of crystals and the gold is recovered as a black sludge, which is treated with sulfuric acid for purification, after which it is treated by the Wohlwill process for production into refined gold. The desilverized lead is treated by the Betterton process for the removal of bismuth, and is then cast into 100-pound pigs.

The smelter gases are conducted through a bag house for the recovery of lead fumes. The fumes are cooled and then filtered in long woolen bags. The bags are shaken periodically and the dust and fume is collected at the bottom. The barren gases are conducted to the exhaust stack. The stack, second tallest in the world, is 605 feet 9 inches high and is an easily recognized landmark. Part of the gases from the sintering machines are high in SO_2 content and are conducted to a plant for

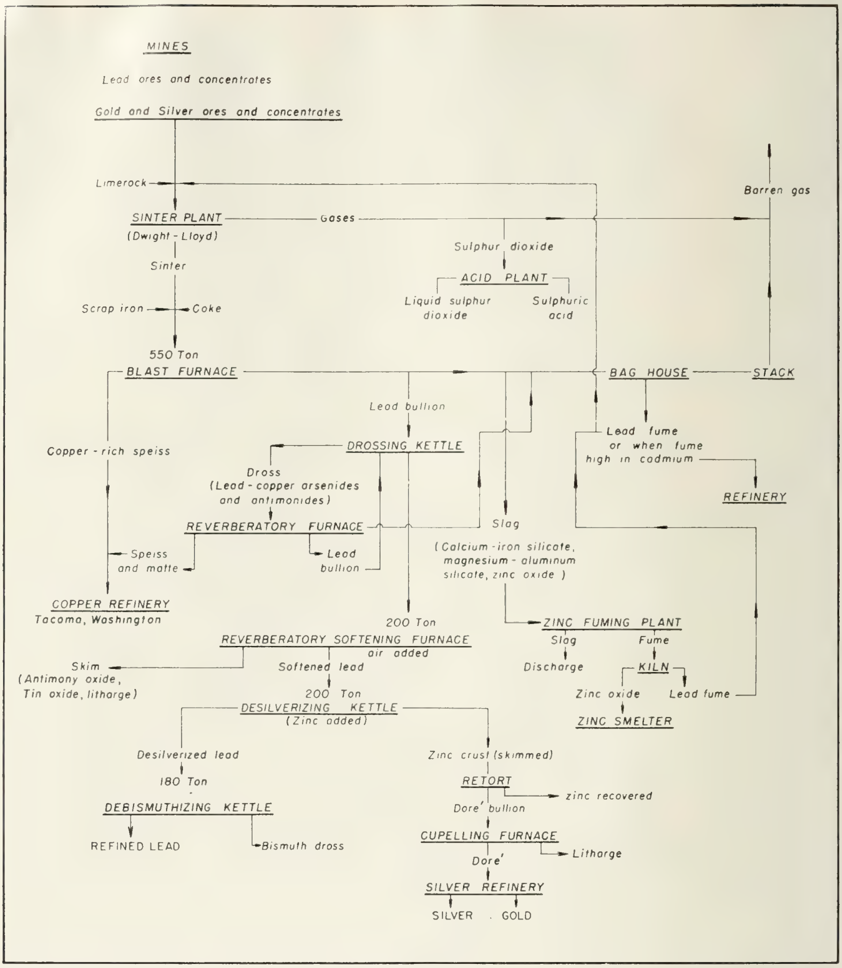

FIGURE 2. Flow sheet of Selby lead smelter (Calif. Div. Mines Bull. 176, p. 287).

the manufacture of sulfuric acid. Acid is made by the contact process at the rate of about 40 tons per day. Liquid sulfur dioxide is also produced.

During May 1958 the plant was being operated 24 hours a day, 7 days a week, and 535 men were employed.

In April 1953 a zinc slag-fuming unit was added to the Selby plant. A fuming furnace 12 feet long by 8 feet wide by 21½ feet high is charged with hot slag from the lead furnace plus cold slag from the slag-pile that has accumulated over many years. The furnace feed averages approximately 11.5 percent zinc, 0.7 percent lead, 23.5 percent silica, 21.5 percent calcium oxide and 30.5 percent iron oxide. Furnace capacity is 250 tons of hot slag plus 100 tons of reclaimed dump slag per day.

Utah coal is crushed to minus ¾-inch size in a hammer mill, pulverized, and blown through the slag by pre-heated air. A three-stage blower driven by an 800-horsepower electric motor supplies air at the rate of 10,000 cubic feet per minute and at a pressure of 14 pounds per square inch. The coal from the pulverizers is directed to the tuyeres in a primary air stream comprising 48 percent of the air flow.

The combustion gases carry metal vapor and oxide fume from the furnace to a brick-walled spray chamber. The hot gases pass through an 8-foot balloon flue, V-tube coolers, and Labbe coolers to the baghouse. En route the temperature drops from 2300° Fahrenheit at the furnace to 200° Fahrenheit.

A de-leading kiln, 7 feet by 75 feet, treats dust from the flue, coolers, and baghouse, volatilizing the lead with the addition of 1 percent coke breeze. The lead dust recovered assays approximately 45 percent lead and 10 percent zinc. It is pugged and returned to the smelter.

The densified zinc fume is recovered at the coolers as a product assaying approximately 78 percent zinc, and less than 1 percent lead. Recovery is estimated at 13,500 tons of zinc fume or 10,400 tons of zinc per annum. This product is crushed and screened to minus ¼-inch size and shipped to zinc smelters for recovery of the metal (Eng. and Min. Jour., Dec. 1953).

Limestone, Lime and Cement

The Mount Diablo quarries near Pacheco were the site of the first lime-making in California after the American occupation. This began in the spring of 1851 (Logan 1947) although no records of production previous to 1903 are available. The Henry Cowell Lime Company reported lime production from 1903 until 1915, excepting 1906 and 1908. The limestone was originally hauled from the quarries on Lime Ridge 3 miles southeast of Concord to Concord where the kiln was located. Later, four standard continuous kilns were installed immediately below the quarry.

The Henry Cowell Lime and Cement Company erected a cement mill at Cowell about 3 miles southeast of Concord in 1907. This dry-process plant went into production in 1908 using as raw material the travertine and clay deposits from the west slope of Lime Ridge immediately south of the plant. Cement was produced continuously from 1908 to 1946 except for a temporary shutdown in 1942, owing to strike conditions· Loss of railroad facilities to the U. S. Navy and the approaching depletion of the limestone deposits caused permanent closing of the plant in 1946. Rated production capacity was 4800 barrels of cement per day and between 200 and 250 people were employed at the plant. In 1952 all the mill equipment was sold at auction. The principal building is currently used as a warehouse (1958).

The Spreckels Sugar Company quarried travertine from pits located south of the Cowell quarries for many years previous to 1915. This stone was shipped to the sugar refinery at Crockett and to the Selby smelter. At the latter plant it was used as a flux for smelting gold, silver and lead ores. This property was purchased by the Henry Cowell Lime and Cement Company in 1916.

PHOTO 1. Cowell limestone quarry.

The Mount Diablo Lime Marl Company produced travertine from 1924 to 1927 which was crushed for agricultural use. These operations were probably centered on Lime Ridge in section 7 where there are three discontinuous small shallow pits.

The principal limestone deposits are located on the west slope of Lime Ridge, a northwesterly spur of Mount Diablo. They extend over a linear distance of nearly 3 miles, from section 7, to section 20, T. 1 N., R. 1 E., M. D., projected. Most of the production came from deposits southeast of the highway in section 17.

The limestone deposits are surficial masses of travertine of Quaternary age which originated from calcareous springs issuing along a fracture in the underlying sedimentary rocks of the Tejon formation (Eocene). Vertical dips in the Tejon rocks along the highway were noted in this vicinity. Although the travertine crops out on the surface at many points along Lime Ridge, the deposits are more frequently obscured by a thin mantle of dark brown soil, calcareous tufa, marl or chalky clay, 5 to 15 feet thick.

The central core of the travertine is pale blue in color, grading outward to a buff-colored stone. The weathered surface is whitish gray and the outer surface of the buff stone is frequently lined with a selvage of white chalk. Textural gradations can also be seen from a central core of hard, fine-grained travertine outward into calcareous tufa and marl. The solid travertine exhibits faint banding and swirling. Differential weathering along the bands has given rise in many places to a porous texture. The travertine has been slightly fractured subsequent to deposition; the fractures have been filled with secondary calcite.

The travertine has been mined from an innumerable series of shallow cuts, pits and benches which frequently merge from one into another. Many bench-cuts range from 5 to 50 feet high and are a

quarter of a mile long. The largest pit is located about a mile south of the cement mill. It has a face about 200 feet high above the water level in the pit and extends for about half a mile laterally. Small tonnages of good minus 12-inch stone are distributed irregularly in piles along the hummocky floor.

A smaller pit immediately to the south explores a face of travertine about 25 by 25 feet in size which grades outward into calcareous tufa. Apparently the miners attempted to follow and mine the central high grade cores of travertine and when these passed into tufa the pit was abandoned. Although these travertine deposits were not originally regarded with great favor in some quarters, they produced cement rock in sufficient quantity to run the cement plant continuously for almost 40 years.

Lenses of limestone are common in the Cretaceous and Tertiary sedimentary rocks of the county. The following quotation describes the nature and distribution of limestone in the Concord quadrangle west of Mount Diablo:

> A few thin lentils of limestone occur in the Cretaceous rocks, but they have no commercial value. There are also many lentils of impure ferruginous and phosphatic limestone in the bituminous shales and cherts of the Monterey group.
>
> In the Orinda and Siesta formations limestone lenses occur more or less persistently at several horizons, and similar beds of limestone are interstratified with the lavas of the Moraga formation. All these lenses are of lacustral formation and most of them are siliceous. The best that can be said of them as to their economic value is that some of them may prove to be of service for local use (Lawson 1914).

The Orinda, Siesta, and Moraga are Pliocene formations which crop out in the hilly area between Mount Diablo and San Francisco Bay. The limestone in the Siesta formation is tan, dense and amorphous.

Manganese

Two of the most common manganese minerals are the oxides pyrolusite (MnO_2) and psilomelane ($BaMn_9O_{18} \cdot 2H_2O$?). These and other manganese minerals are often intimately associated and hence an accurate identification of them in the field is not always possible. Their weight (specific gravity 4.5) and their black sooty nature are the principal means of distinguishing these oxides from other minerals and rocks.

Only one potentially commercial deposit of manganese is known in Contra Costa County. This deposit lies on the southwest side of Red Rock Island, in San Francisco Bay, 1 mile southwest of Point Castro, in section 17, T. 1 N., R. 5 W. (projected). The deposit was described by Lawson (1914). Essentially the same description has been included in previous Contra Costa County reports and in a recent Division of Mines Bulletin (Trask, 1950). The manganese mineral psilomelane is rhythmically interbedded with red radiolarian chert of the Franciscan formation (Upper Jurassic). The beds have a near-vertical dip and strike west-northwest. Most of the psilomelane layers are 0.2 to 0.5 inch thick. The width of the manganese-rich zone in the chert has not been determined. Production in 1867 of possibly 200 tons of ore from this deposit has been reported (Jenkins, 1943).

In a previous report small bunches of manganese have been mentioned as occurring on the southeastern side of Mount Diablo (Laizure, 1927).

Mercury (Quicksilver)

Occurrences of the mercury minerals, cinnabar and metacinnabar, have been noted in the Franciscan rocks of Mount Diablo. The only commercial deposit of mercury in the area has been exploited at the Mount Diablo mine.

Mount Diablo Mine (Rhyne). Location: E½ Sec. 29, T. 1 N., R. 1 E., consisting of about 100 acres on the northeast slope of the North Peak of Mount Diablo about 4 miles southeast of Clayton. Ownership: Mount Diablo Quicksilver Co., Ltd., Vic Blomberg, President, P. O. Box 133, Clayton, California.

The geology of the Mount Diablo area was described in considerable detail by Taff (1935). He showed that the central core of the mountain, covering about 20 square miles, is composed of sedimentary (sandstone and shale), igneous (diabase, basalt, and gabbro), and metamorphic rocks (serpentine, schists and meta-chert) of the Franciscan formation of Jurassic (?) age. This central core is surrounded by later sedimentary rocks ranging from Cretaceous to Pliocene age totaling 35,000 feet in thickness. Taff believed that the core of Franciscan rocks was squeezed upward through the cover of post-Franciscan rocks during the Quaternary period. This type of structure is known as a 'piercement' and examples have been noted at other localities in the Coast Ranges. The mercury minerals occur in the sheared contact zone between the Franciscan sedimentary rocks and the intrusive serpentine especially where the serpentine has been subsequently altered to silica-carbonate rock.

A report on the geology of the Mount Diablo mine was made by Ross (1940). Here, the Franciscan strata occupies the footwall and dips about 45° northeastward. Shear zones along the contact between the Franciscan rocks and the overlying serpentine control the distribution of the ore. Minor fractures normal to the shear zones have exercised local control over mineral deposition.

The Mount Diablo mine is distinctive in that metacinnabar, the black sulfide of mercury, is one of the principal ore minerals. This mineral is common at many mercury mines but is seldom present in sufficient quantity to be ore. Cinnabar is the other ore mineral. Minerals also found in the mine are marcasite, pyrite, quartz, chalcedony, carbonates (dolomite and calcite), chromite, nickel silicate, iron sulfates, and epsomite.

The serpentine mass explored in the mill workings was mostly altered to silica-carbonate rock. It averaged about 200 feet long, measured from 50 to 100+ feet thick, and extended at least 400 feet on the dip of N. 50° E.

Regarding the origin of the mineral deposits, Ross states:

> The lodes of the Mount Diablo district appear to have been deposited from hot waters that derived their metallic constituents from distant magmatic sources. Deposition took place in successive stages relatively close to the surface and in geologically recent time. It was confined to zones of crushing and shearing that served as channels for the rising solutions and provided adequate open spaces for deposition of the sulphides. . . . The most distinctive characteristics of the Mount Diablo district are the relative abundance of metacinnabar, sulphates, and gases. In the Mount Diablo area the rock is perhaps more extensively crushed and the amount of open space that has survived mineralization is even greater than in other districts. These distinctive features are all in accord with the concept that the lodes of

the Mount Diablo district formed close to the surface and more recently than many of the others in the Coast Ranges. This statement does not necessarily imply that they belong to a different period of ore deposition.

Deposits thus formed are shallow as compared with many kinds of metalliferous lodes, but the vertical range in which they may occur is far greater than that yet explored in the Mount Diablo district. Ore shoots may have originally formed at intervals through a vertical distance of hundreds or more, probably thousands of feet, and the deposits in this district are so recent geologically that the depth of erosion since mineralization probably has not been great. A more potent factor in respect to practical limits of depth is the fact that ore shoots are so small and so irregularly distributed that their positions are difficult to predict. The relatively light load under which the lodes were formed is in part responsible for these conditions.

The warm springs near the Mount Diablo mine and those near other quicksilver mines may represent dying stages of the hot-spring activity that produced the mineral deposits. The gases that still circulate through the lodes are likewise related to hot-spring processes. It does not follow, however, that either modern hot-spring water nearby or gases within the mines have the same composition as the solutions from which the ore minerals were deposited. The presence of both pyrite and marcasite and of both cinnabar and metacinnabar shows clearly that changes in the character of the solutions occurred while mineralization was in progress. Other such changes have surely occurred since it ceased.

It seems clear that nearly all of the sulphide minerals are products of the original mineralization, deposited from ascending water. The metacinnabar is earlier than much or all of the cinnabar. The cinnabar, which is the more stable form of quicksilver sulphide, may have formed in part by inversion from the previously crystallized metacinnabar. At all events, it seems clear that the metacinnabar in the crystalline aggregates of botryoidal form is not a supergene product, as this mineral is commonly supposed to be. Chemical data, recently summarized by Dreyer [1940] show that metacinnabar may be formed from rising solutions in an acid environment and may invert into cinnabar.

The presence of cinnabar on the northeastern slope of Mount Diablo was known since boyhood to the oldest Indians in the area and was used by them in preparation for tribal ceremonies and war-like adventures. An early account (Mining and Scientific Press, 1865) states that the deposit was located about 1863 by a Mr. Welch who sank a 35-foot shaft to intersect the ore at depth, and that both native mercury and cinnabar could be obtained by panning the soil removed in this work. Locations were subsequently made both north and south of the original claim and a placer location was made at a lower elevation where both mercury and cinnabar were recovered by panning.

A short period of production occurred from 1875 to 1877 but the exact quantity produced is unknown. An old report (Ireland 1888) states "it is said to have produced 85 flasks of quicksilver per month". Judging by the size of the dumps, however, subsequent operators have expressed doubt that production was maintained at this rate for any appreciable time. Consequently we have tentatively credited this period with a total production of 1000 flasks.

Except for sporadic efforts the mine lay idle until 1930 when it was reopened by the Mount Diablo Quicksilver Mining Company who made a small production in 1930. In December 1930 the Mt. Diablo Quicksilver Co., Ltd., was organized under the laws of the state of Nevada to acquire the property and to develop the mine under lease royalty arrangements with operating companies. Some exploration work was done in 1931 and a small production was made in 1932 by treating the ore in a 7-tube retort. C. W. Ericksen operated the mine during the first part of 1936 and installed a rotary furnace to treat the ore. The first major lessee was the Bradley Mining Company, San Francisco, who began operating the mine in the latter part of 1936.

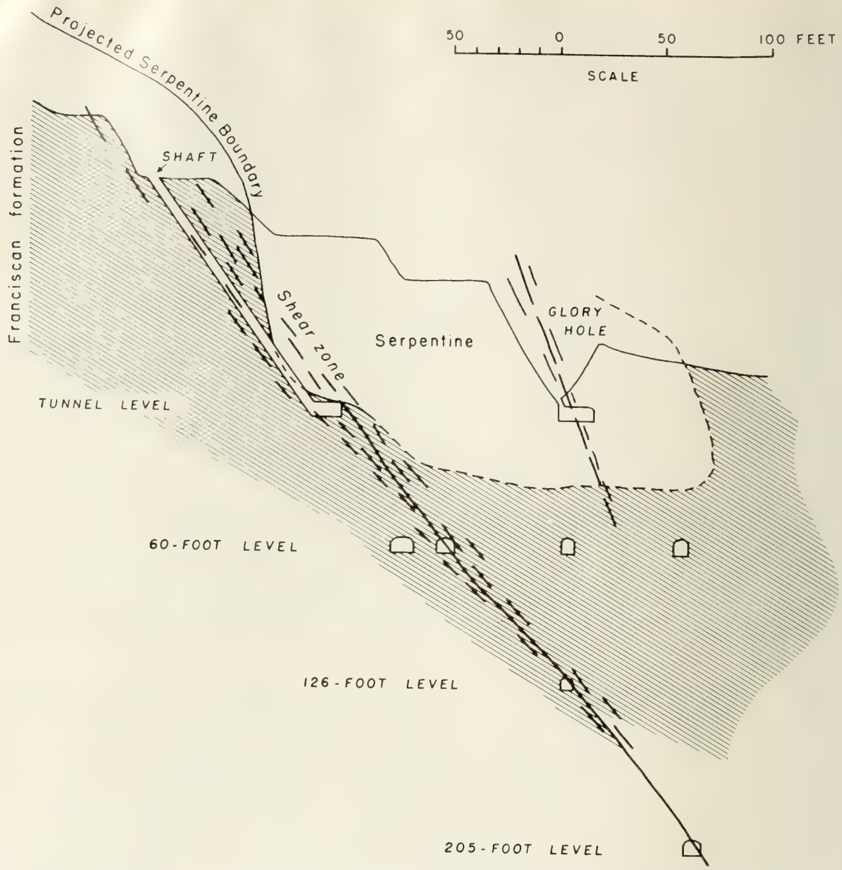

FIGURE 3. Section through Mill workings, Mt. Diablo mercury mine (from U. S. Geological Survey Bull. 922-S, p. 48).

The development of the deposit has been localized in two areas: the Rhyne-Jones and the Mill workings. The Rhyne-Jones area (about 1500 feet west of the millsite) was the locus of the earliest underground mining. This work included the Rhyne and the Jones tunnels, consisting of about 1200 feet of adits and drifts, which explored a breccia zone trending northwestward. Some mining was done by the Bradley Mining Company in the Rhyne-Jones area. Most of their mining however was concentrated on the shear zone at the Mill workings which had been ignored or overlooked in earlier work.

Mill workings were opened or extended in 1936 and the surface excavations eventually included 4 benches and a glory hole. An adit with portal below the mill provided entry to the underground workings. Three lower levels at 126, 160, and 205-foot points were reached by winzes. The workings of the mine, including the surface cuts, extended through a vertical distance of about 500 feet and aggregated about 4000 linear feet. Stopes averaged about 20 feet in width and extended from 100 to 150 feet in length.

The Bradley Mining Company produced mercury from 1936 to 1946 inclusive. As the termination of World War II approached, a decline in the price of mercury began which eventually halted the profitable mining of the metal. Shortly after the mining of mercury ore ended in 1946, crushers were installed to produce crushed rock from silicified Franciscan sandstone. The plant was in continuous operation for about 8 months but competition from more favorably located plants forced cessation of this operation. Production of crushed rock in March 1951 was on an intermittent basis. No mercury production was made from 1947 to 1951 and the company surrendered the lease in the latter year. Some operating data covering the productive period of the mine was compiled by the company and is presented in table 4.

The price of mercury zoomed upward in the latter part of 1950 when war broke out on the Korean peninsula. About the middle of 1951 the mine was leased to Ronnie B. Smith, Dallas, Texas. Operations were concentrated in the open pit at the Mill workings. Two horseshoe-shaped benches with 30-foot faces were mined using a diesel shovel with a 1-yard dipper and a Caterpillar loader. The ore was loaded to 2 Euclid dump trucks for the short haul to the mill. The ore was "burned" in the rotary furnace and condenser soot was treated in a D-retort. Twelve men were employed.

As a result of the work during 1951-1952 and its past production record, the U. S. Government on June 5, 1953 granted the mine a Defense Minerals Exploration loan in the amount of $125,000. This contract called for underground exploration beneath the mill pit with the hope of finding a mineable ore body at greater depth in the shear zone.

A 40-foot headframe, carrying a 5-foot sheave strung with a ⅜-inch cable, was erected and a 40-horsepower hoist was installed. An exploratory, 2-compartment shaft (4½ by 8½ feet in the clear) was sunk on the north side of the pit. At a point 300 feet below the shaft collar, a 5 by 7-foot drift was headed southwestward toward the shear zone which lay at an estimated distance of 120 feet.

In January 1954 Smith assigned his lease to J. L. Jonas and J. E. Johnson. Shortly thereafter the new lessee encountered underground operating difficulties owing to the presence of gas (hydrogen sulfide, sulfur dioxide and methane). The mine was closed and remained idle during the remainder of the year.

In February 1955 the Cordero Mining Company, Palo Alto, obtained the lease and completed the exploration contract which called for 910 feet of crosscuts and drifts on the 300-foot level. It was reported that four leads were uncovered and a small tonnage of 3- to 7-pound ore was found. The showings were not considered sufficient to warrant further operation by the company and the lease was terminated. No certification of discovery was made by the Defense Minerals Exploration Administration.

In 1956 the Nevada Scheelite Company leased the mine and installed a deep-well pump (550 gallons per minute) to remove the water which had risen to a point 112 feet below the collar of the shaft. Since the down-stream ranchers objected to the discharge of acid mine water into the creek this work was suspended. Attention was then directed

Table 4. Production and costs, Mt. Diablo mine, 1936-1946.*

	Flasks	Pounds of mercury	Dry tons of ore	Pounds of mercury per ton of ore	Operating cost	Average[1] California price per flask	Operating cost per flask	Operating cost per ton of ore	All cost	Total cost per flask	Total cost per ton of ore
1936	22	1,672	334	5.0	$3,311	$77	$150	$9.91	$19,676	$894	$58.9
1937	304	23,104	2,725	8.5	44,260	84	146	16.20	61,745	203	22.7
1938	1,422	108,072	8,850	12.3	85,355	70	60	9.60	91,573	64	10.3
1939	1,423	108,148	12,003	9.0	94,839	98	67	7.90	106,717	75	8.9
1940	1,216	92,416	19,003	4.9	110,450	170	80	5.80	122,006	100	6.4
1941	1,506	114,456	19,201	6.0	148,282	176	98	7.70	160,534	107	8.4
1942	1,337	101,612	19,514	5.2	143,167	185	107	7.30	147,520	110	7.6
1943	1,312	99,712	16,570	6.0	149,247	181	114	9.60	168,692	129	10.2
1944	493	37,468	7,438	5.0	57,441	113	117	7.70	53,223	108	7.2
1945	502	38,152	8,808	4.3	69,239	128	138	7.90	83,823	167	9.4
1946	918	69,768	12,198	5.7	112,216	92	122	9.20	114,898	125	9.4
Total	10,455	794,580	126,664		$1,017,807				$1,130,407		
Average				6.3		$125	$97	$8.00		$108	$8.9

* Data from Bradley Mining Co.
[1] California Division of Mines.

to the open pit where some exploration was done using wagon drills. A small tonnage of retort-grade ore was developed. Since this was not sufficient to satisfy the requirements of the company the lease was relinquished.

No production of mercury was reported during or since completion of the DMEA contract. The mine has remained idle from 1956 to date (July 1958) and the shaft and underground workings have filled with water. The flow of water on the 300-foot level is reported to be 150 gallons per minute. During the stormy winter season the underground water can be diverted into the creek without damage to downstream neighbors. During the summer and period of low-creek flow however, the mine water must be pumped to surface sumps and aerated or treated with lime before diversion.

The mine ore transfer system consists of a 50-ton coarse mine-ore bin, feeding the ore to a 10 by 12-inch Pacific jaw crusher, dropping the minus $1\frac{1}{2}$-inch crushed ore to a 125-foot conveyor belt which conveys and deposits it in a 90-ton fine ore bin.

The ore treatment plant consists of a 42-foot Gould rotary counter-current furnace of 50-ton per day capacity. It's equipped with a dust collector, condensers, exhaust fan and stack. Auxiliary equipment includes: D-retort, mud machine, 30 cubic foot plant compressor, 210-foot air compressor (diesel driven), 15,500-gallon fuel storage tank, water well system. Buildings include a bottling and flask storage house, blacksmith shop, equipment shop, warehouse, 7-room bunkhouse, 6-room cookhouse, and 3 residence houses.

Total reported production throughout the entire life of the mine has been slightly over 11,000 flasks.

Mineral Springs

The medicinal value of mineral waters has been recognized for centuries. During the 19th century California demonstrated that her mineral springs were as valuable and efficacious as any in the world. Health resorts that were established at the site of the most accessible and salubrious springs enjoyed great vogue until the automobile became a common means of transportation about 1920. Thereafter the population grew more restive and the popularity of the spas declined.

Most of the springs of Contra Costa County were described by Waring in 1915. The Twenty-seventh Report of the State Mineralogist contains a summary of Waring's description and some data on the waters of Alhambra, Byron, Ferndale, Pine Canyon and Sulfur Springs.

Mineral water has been produced almost continuously in Contra Costa County from 1896 to 1951. Data on the quantity and value of mineral water bottled for sale are included in the county statistics from 1896 to 1946 inclusive. Since 1951 Alhambra Springs south of Martinez has been maintained in stand-by condition but has made no production. Oak Springs water has not been usable since 1951 owing to the encroachment of local inhabitants.

A table summarizing data on the springs which have produced water for sale in the county will be found at the end of this report.

Byron Hot Springs. Location: Sec. 15, T. 1 S., R. 3 E., M. D., 1½ miles south of Byron. Ownership: R. H. Barr, 605 Market St., San Francisco.

The Spanish explorers found Indians encamped near Byron Hot Springs to bathe in the sulfurous mud and drink the iron-bearing waters (Anderson 1892). In 1861 R. O. Risdon gained control of the property. In 1868 he established a health resort which became famous throughout the state for the curative power of its waters. The resort was destroyed by fire and rebuilt a number of times, notably in 1903 and 1915. During World War II the property was used as an internment camp for high-ranking prisoners of war. It is currently unoccupied excepting for a caretaker (June 1958).

Over 50 springs are found in the group but only 7 have been exploited. The temperature of the various springs ranges from 52° F to 140° F.

Natural Gas and Petroleum

Contra Costa County's first well was the second one drilled for oil in California (Whitney, 1865). It was drilled in 1862 on the west side of San Pablo Creek, 4 miles southeast of San Pablo. In 1864, a well drilled near oil seeps on the northeast flank of Mount Diablo probably in section 24, T. 1 N., R. 1 E., 1½ miles south of the old Empire coal mine, yielded several barrels of green-colored oil of high specific gravity from a depth of 300 feet from beds of undetermined age. Other wells in the area had similar success.

In the lower San Pablo Valley, about 3 miles east of San Pablo, five wells were drilled into the Orinda formation (Pliocene) near seeps of black asphaltic oil (Vander Leck 1921). Some oil and gas was encountered but commercial production was not established.

Traces of petroleum were obtained by wells drilled in the so-called Minor Ranch oil field on Lauterwasser Creek, 1 mile north of Orinda. A report on this field was prepared by Arnold in 1907. At that time eight wells had been drilled, all on the south side of Lauterwasser Creek. The wells ranged in depth from 570 to 2,750 feet, being drilled in the northeast flank of the Minor Ranch anticline. The anticline trends and plunges southeast, crossing the creek about a mile northeast of Orinda, and is truncated on the northwest by a fault. Oil accumulations found in the anticline are in the sandy beds of the Orinda formation, which is underlain by shale beds of the Monterey group (Miocene). Gas was encountered in all wells and oil in some. One well is said to have produced 300 barrels of low-specific gravity oil from a depth of about 1300 feet. Gas from the field has a calorific value in excess of 1000 British thermal units, according to Arnold, who concludes that future drillers in this area should expect results similar to those previously obtained.

In 1930-31 the Orinda Petroleum Company, Ltd., drilled a test on the Glorietta anticline 1 mile south of Orinda in section 32, T. 1 N., R. 3 W. Gas pressures of 240 pounds were developed, and cores from 777 feet to the bottom were cut, but the test was abandoned at 3033 feet because the capacity of the drilling equipment had been reached.

The deepest test in Contra Costa County was drilled by the Tassajara Oil Corporation in section 9, T. 2 S., R. 1 E., in 1938 and 1940. This test hole, which had a total depth of 9777 feet, encountered tight oil sands from which production could not be obtained. The test was located on a surface fold.

The Rio Vista gas field in Solano County was discovered by the Amerada Petroleum Corporation in 1936. The field was eventually extended southward into Contra Costa County from the point of discovery and has been described by Frame (1944 and 1948) and Corwin (1953). The wells penetrated sedimentary rocks which range in age from Recent (alluvium) to Cretaceous. The structure of the field is a broad, northwest-trending, faulted, elongated dome. The northwest-striking Midland fault divides the field into two parts. Five productive zones in Eocene sediments have been encountered at depths ranging from 3900 to 5800 feet. The Emigh zone is the most productive; west of the Midland fault it is several hundred feet deeper than on the east side of the fault. A well in the field penerated 11,051 feet, bottoming in Cretaceous. It is estimated that the field originally contained 3,536,-793,000 thousand cubic feet of gas. At the end of 1956 reserves were estimated to be 1,248,922,282 thousand cubic feet. During 1956 the field produced 38,023,254 thousand cubic feet of natural gas. The heat content of the gas from this field is high (1,040 British thermal units per cubic foot) compared with other dry natural gas fields in the state. During the last half of 1955 the field had 177 potentially productive wells; of these 152 were actually producing (Musser 1956). The proven area in Contra Costa County totals 1103 acres.

Producing and non-producing wells in the Contra Costa County end of the Rio Vista gas field are listed in table 5 and are also shown on plate 1. A map of the Rio Vista gas field has been published by the California Division of Oil and Gas.

Table 6 lists the dry holes drilled in Contra Costa County outside of the Rio Vista gas field.

Table 5. Wells in the Contra Costa County end of the Rio Vista gas field.†
Location: T. 3 N., R. 3 E., M. D.

Map No.	*Section*	*Wells*
15	20	Bradford Community 1
16	20	Bradford Community 2
17	20	Bradford Community II-3
18	21	Bradford Community 4
19	20	Bradford Community 5
20	20	Bradford Community 6
21	28	Floto 1
22	28	Floto 2
23	29	Jordan Unit 1
	29	Jordan Unit 2*
24	29	Jordan Unit 3
	23	Productive properties 1*
	28	Productive properties 2*

* Uncompleted well.
† Wells are owned by the Standard Oil Company of California.

In May 1958 the McCulloch Oil Exploration Company of California, Inc., brought in "McCulloch-Marson-Ginochio," a gas well which flowed at the rate of 1,000,000 cubic feet of gas per day through a

Table 6. Exploratory wells drilled for oil and gas in Contra Costa County outside of Rio Vista gas field *

T.	R.	Sec.	B&M	Name of company and well	Date started	Date abandoned	Total depth (feet)	Geology of bottom
3N	3E	22	MD	Christopher Oil Co.; Shafer-Louden 4	4-30-55	5- 9-55	4650	Ran electric log, plugged.
3N	3E	34	MD	Shell Oil Co.; Webb Tract I	6-52	1952	5000	Lower Eocene (?)
2N	4W	29	MD	Sobrante Oil & Inv. Co.; No. 1	-------	1900	100+	
2N	4W	32	MD	Fairmeade Petroleum Co.; Core Hole 2	7-41	1942	700	
2N	3W	21	MD	Standard Oil Co.; Fernandez Community 1	9-48	1948	6607	Eocene.
2N	2W	31	MD	Ardley Pet. Co.; Almond 1	3-45	1947	2202	
2N	2W	31	MD	Ardley Pet. Co.; Almond 2	3-50	1950	3116	Cretaceous.
2N	2W	31	MD	Ardley Pet. Co.; Almond 3	6-50	1950	3188	Cretaceous.
2N	2W	31	MD	Edwards, Wm.; Hanos Ranch 1	9-24	1925	2365	Monterey.
2N	2W	31	MD	Lightning Gas & Oil Co.; Almond 5	6-6-54	7-16-54	5000	Formation test 3764-3904 feet, med. steady blow decreasing to weak; recovered 230 feet fluid. Minor showing 4990-5000; ran electric log.
2N	2W	31	MD	Lightning Gas & Oil; Almond 6	9-12-54	9-30-54	4024	Electric log; no tests.
2N	2W	31	MD	Lovely Pet. Co.; Almond 4	9-51	1951	4610	Gas show 1600-1610 feet.
2N	1W	17	MD	Baldwin, Joh, Oper.; Baldwin-Soite 1	12-51	1952	5488	Non-commercial gas shows from 4200-4261 feet; Nortonville 3375 feet, Domengine 3820 feet, top Capay 4400 feet, Martinez 5138 feet, Cretaceous 5460 feet; bottomed in Cretaceous.
2N	1W	18	MD	McCulloch Oil Exploration Co., Inc.	3-22-58	---------	4024	Electric log; no tests.
2N	1W	21	MD	Cal-Bay Corp.; Faria 1	7-43	1945	4975	Eocene.

2N	1W	26	MD	Standard Oil Co. of California; Keller 1	6-43	1943	4133	Cretaceous.
2N	2E	24	MD	Sesnon, P., W. T., Cartan, B. S.; Sesnon 1	12-49	1950	6951	Markley (base Sidney) 4317 feet, top Nortonville shale 4592 feet, top Domengine green sand 5104 feet, top Capay 5858 feet, top Margaret Hamilton sand 6915 feet.
2N	2E	34	MD	Standard Oil Co.; Canada Comm. 1	11-50	1950	2835	Eocene.
2N	3E	4	MD	Trico Oil & Gas Co.; Trico-Signal 1	6-43	1943	4350	Eocene.
2N	3E	9	MD	Tide Water Associated Oil Co.; Bethel Island Comm. 1	4-42	1942	4975	Eocene.
2N	3E	10	MD	Shell Oil Co.; Bethel Core Hole 1	5-51	1951	5420	Paleocene.
1N	4W	4	MD	Laymance, J. W.; No. 1		1899	170	
1N	4W	4 or 9	MD	East Richmond Oil Co.; No. 1	1909	1909	500	
1N	4W	5 or 6	MD	San Pablo Oil Co.		1900	670	
1N	4W	8	MD	Mount Diablo Oil Co.		1900	170	
1N	4W	10	MD	Mt. Diablo Oil Co.; No. 1		1900	400	
1N	4W	10	MD	Mt. Diablo Oil Co.; No. 2		1900		
1N	4W	10	MD	Mt. Diablo Oil Co.; No. 3		1900	1200	
1N	4W	10	MD	Mt. Diablo Oil Co.; No. 4		1900	1000	
1N	3W	6	MD	Standard Oil Co.; Oursan Comm. 1	10-43	1944	4270	Cretaceous.
1N	3W	13	MD	Shell Oil Co., Inc., East Bay 1	10-44	1945	8408	Chico (?)
1N	3W	26 or 35	MD	Leachman and Marshall; No. 1	5-24	1927	450	Monterey.
1N	3W	27	MD	Chandler; No. 1		1889	200+	
1N	3W	27	MD	Cummings; No. 1		1895	300+	
1N	3W	27	MD	Sontag; No. 1		1896	100+	
1N	3W	27	MD	Miner Ranch; No. 3		1896	570	

*Table 6. Exploratory wells drilled for oil and gas in Contra Costa County outside of Rio Vista gas field *—Continued*

T.	R.	Sec.	B&M	Name of company and well	Date started	Date abandoned	Total depth (feet)	Geology of bottom
1N	3W	27	MD	Miner Ranch; Nos. 4, 5, 6, 7, 8				Drilled 1864-1900; 570-2750 feet. One well reported oil at 1300 feet ±, flowed 900 barrels in 9 hours (?)
1N	3W	27	MD	Tidewater Oil Development Co.; No. 1		1904	300	
1N	3W	32	MD	Grand Pacific Oil Co.; (1 or more wells)		1900		
1N	3W	32	MD	Orinda Petroleum Co., Ltd.; No. 1	4-30	1936	3303	
1N	3W	33	MD	Central California Oil Co.; Old Flood 1	7-22	Pre-1925	1640	Monterey.
1N	3W	33	MD	Central California Oil Co.; Old Flood 2	1901?	1926	305	
1N	2W	28	MD	Lafayette Oil Co.; Morris 1	4-41	1941	1580	
1N	2W	28 or 29	MD	National Paraffin Co.	1900	1900	1694	
1N	1E	13 or 14	MD	Cruikshank, J. W.: Nos. 1, 2, 3, 4, 5				Wells started approx. 1864 and drilled to 300 feet +.
1N	1E	15	MD	Harding Well; No. 1	1920	1920	987	
1N	1E	15	MD	Atlas Development Co.; No. 1	1-18	1919	1823	
1N	2E	4	MD	Shell Oil Co., Inc.; Heidorn 1	5-44	1944	4048	Middle Eocene.
1N	3E	29	MD	Bender, E. A.; Wallace 1	3-50	1950	4659	
1N	3E	30	MD	Ohio Oil Co.; Brentwood Farms 1	6-48	1948	5456	Eocene.
1S	3E	9	MD	Ohio Oil Co.; Core Hole 1	7-47	1952	1717	Nortonville 1500 feet; bottomed in Eocene.
1S	3E	9	MD	Ohio Oil Co.; Core Hole 2	8-47	1952	2349	Nortonville 2210 feet.

1S	3E	9	MD	Ohio Oil Co.; Core Hole 3	8-47	1952	3142	Nortonville 3070 feet.
1S	3E	14	MD	Standard Oil Co.; Sproule 1	12-49	1949	6070	Cretaceous.
1S	2E	19	MD	Davidor & Davidor; L. Souss 1	11-4-57	12-3-57	3911	Drilled Cretaceous.
1S	1W	31	MD	Buttes Gas & Oil Co.; Buttes-Otto 1	6-30-56	8-29-56	6695	Recovered some 45° oil on drill stem test at 1022 feet and 2600 feet. Non-commercial.
1S	1W	31	MD	Buttes Gas & Oil Co.; Butte-Costa 1	9-6-56	9-24-56	3376	Ran electric-log and cored bottom, siltstone.
2S	1W	10	MD	Buttes Gas & Oil Co.; Butte-Wodemann 1	9-5-55	11-18-55	9278	Oil shows not commercial, plugged.
2S	1W	19	MD	Elsinore Oil Co. of Nevada; No. 1	10-23	1923		
2S	1W	25	MD	Brady Sure Shot Oil Co.; No. 1	4-24	1925	300	Miocene.
2S	1E	9	MD	Tassajara Oil Corp.; Rasmussen 1	11-39	1940	9777	Miocene.

* Data from California Division of Mines Special Report 45, supplemented by Munger Oilgrams.

$\frac{3}{8}$-inch bean. Pressure was about 500 pounds per square inch. The well is located 20 feet south and 2000 feet west of the northeast corner of section 18, T. 2 N., R. 1 W., M.D., about $1\frac{1}{2}$ miles southeast of Port Chicago.

The well was spudded on April 15 at an elevation of 542 feet. The top of the Nortonville sand was reached at a depth of 1666 feet and the top of the Domengine sand at 1864 feet. The total depth was 3021 feet and it was plugged back to 2045 feet (Munger Oilgram, May 6, 1958).

Peat

Peat is the residuum resulting from the arrested decomposition of vegetable matter which accumulates in water-covered or swampy land. The carbonaceous matter in these plants is preserved because of the deficiency of oxygen below the water level. Most of the delta area of the Sacramento and San Joaquin Rivers is underlain by peat consisting primarily of partly decomposed and disintegrated mosses, tules and grasses. These deposits cover an estimated 432 square miles about one-sixth of which lies in Contra Costa County.

Much of the land northeast of the Santa Fe Railway in the northwestern part of the county is peat land but is devoted to agriculture (Laizure 1927). The peat in this area is classified commercially as sedge or reed peat, a grade intermediate between high grade peat moss and inferior peat dirt. The peat deposits as mined are usually less than 20 feet thick although their occurrence to a maximum thickness of 80 feet has been mentioned in the literature (Laizure 1927). Contra Costa was the leading peat-producing county in the state in 1956. Peat in this state is not utilized as a fuel but a substantial market has been developed for it in the horticultural field.

The current production comes from a 2600-acre holding in sections 1, 2, 11, 12, T. 2 N., R. 3 E., M. D. These sections lie in Frank's Tract, an area now covered by 6 to 8 feet of fresh water, but which was formerly farm land protected by levees. In 1927 the area was flooded by a break in the levee on the southwest (Bethel Island) side.

Gambetta. Location: NW$\frac{1}{4}$ section 2, T. 2 N., R. 3 W., M. D. Ownership: P. J. Gambetta, Route 1, Box 78, Brentwood: The plant is located about 6 miles east of Brentwood on Indian Slough, at the end of Point of Timber Road.

Dredging of peat from Frank's Tract began about July 1955 using a combination tug boat and barge. The tug is powered by 2 General Motors 165 horsepower diesel engines and is equipped with 2 electrically operated spuds and a mooring line. On this boat is mounted a Caterpillar diesel dragline consisting of a 50-foot boom and a 1-cubic-yard clamshell bucket. The barge is 6 by $27\frac{1}{2}$ by 96 feet and has a capacity of 600 cubic yards. The complete unit is operated by a 3-man crew and requires $11\frac{1}{2}$ hours for the round trip from plant to dredging grounds, a distance of 18 miles. The peat beds are encountered about 7 feet below the water level and have been mined to a maximum depth of 30 feet. They are underlain by sand. The mining season extends from June to December.

Peat is unloaded onto the 20-acre drying yard where it is spread out about 7 inches deep. Here it is sun-dried for 60 days or until the moisture is reduced to about 700-800 pounds per cubic yard. The peat is then fed to a combination shredder-loader and outloaded to stake-trucks and trailer units holding 30 yards each.

Vita-Peat (California Peat Company). Location: section 10, T. 2 N., R. 3 W., M. D. Owner, F. E. Koser; manager, R. B. Larsen; Bethel Island, California.

The company dredges peat from Frank's Tract using a 1-cubic-yard clamshell bucket and boom mounted on a barge. The peat is now barged to a dock adjoining the drying yard on Bethel Island. Prior to 1951 the drying yard was located at the south end of the Antioch bridge. Peat is sun-dried at the yard and its density is reduced from about 1800 pounds per cubic yard to about 700 pounds per cubic yard. After drying the peat is shredded, and bagged or loaded to trucks for bulk delivery to consumers.

It is packaged in 20-pound, 40-pound, or 100-pound polyethylene-treated bags. Bulk delivery is made in stake-truck and trailer units carrying a total load of 60 tons. The peat is used as a soil conditioner and for compounding with fertilizer. About 10 men are employed in summer and 4 men in winter operations.

Pumice

Deposits of fragmentary pumice occur in the Lawlor tuff and Pinole tuff, volcanic formations of Pliocene age. The Lawlor tuff crops out in narrow belts and as an isolated patch in the southwest quarter of the Antioch quadrangle, extending northwestward into the southeast quarter of the Carquinez quadrangle. This locality is along the north flank of Los Medanos Hills about 4 miles southwest of Pittsburg. The tuff beds range from 50 to 100 feet thick and dip 15° to 40° northeastward. They are overlapped by the Wolfskill formation (Pliocene sandy clay shales, pebbly sandstones and conglomerate) and lie on the Neroly

PHOTO 2. Shredding sun-dried peat at the yard of Vita-Peat Corporation, Bethel Island, Contra Costa County. *Photo by Charles W. Jennings.*

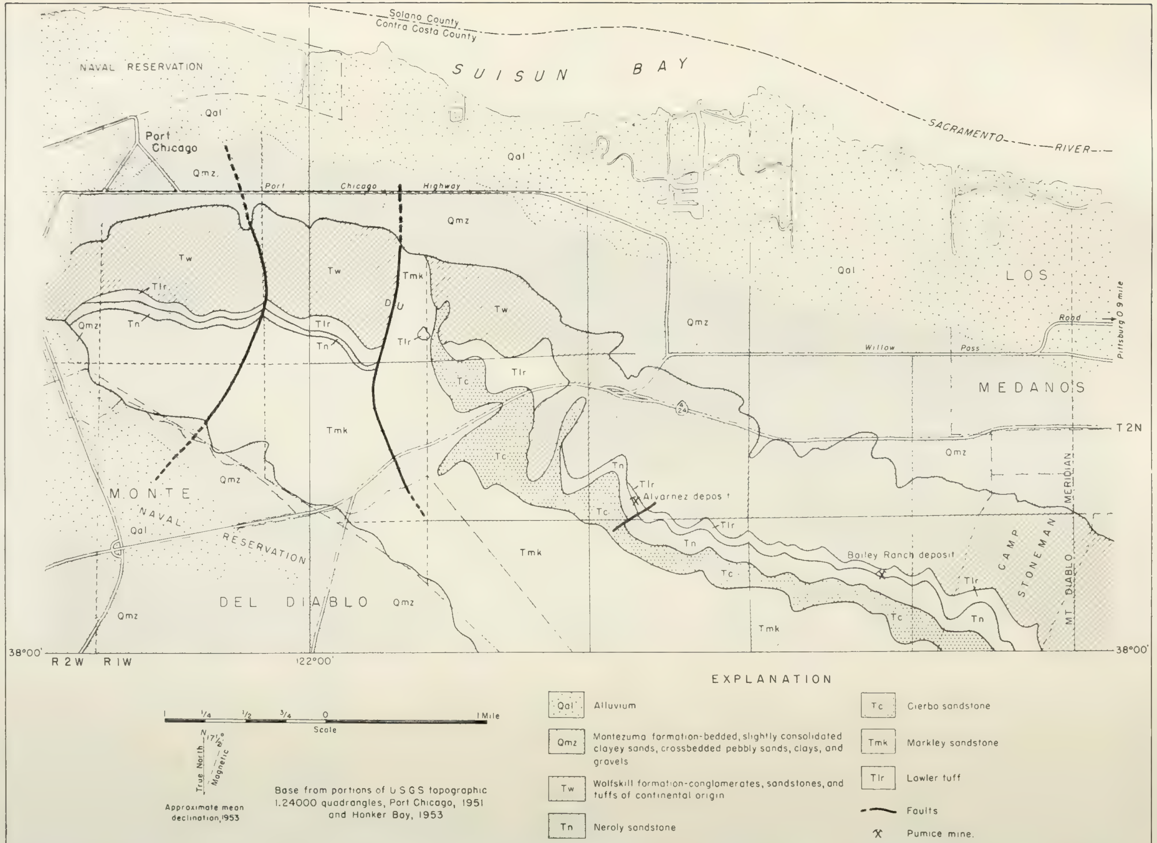

FIGURE 4. Geologic map of the Pittsburg pumice area (Calif. Div. Mines Bull. 174, p. 14).

sandstone of upper Miocene age (Weaver 1949). Chesterman (1956) stated:

> The pyroclastic rock comprising the Lawlor tuff is actually a lapilli tuff. It consists essentially of angular, broken fragments of white and grayish-white pumice which range in size ¼ inch to 2 inches set in a matrix of white pumicite. Broken crystals of feldspar, hypersthene, and green and brown hornblende are present in small amounts. Locally the tuff is well compacted and forms prominent exposures.

Pumice in the Lawlor tuff was mined, screened and sized for use in lightweight building blocks from two localities in the area between 1945 and 1950.

The Pinole tuff is exposed at Pinole and Rodeo in the Carquinez quadrangle and at other localities in the county. From Pinole westward to Wilson Point on the south shore of San Pablo Bay the beds strike east and dip 35° northward.

Chesterman (1956) described the Pinole tuff as follows:

> "The Pinole tuff is made up of a series of lapilli and vitric-crystal-lithic tuff layers, which occur near the base of the Orinda formation (lower Pliocene). The thickest occurrences of the Pinole tuff, and the one that contains the largest rock fragments, is exposed near Rodeo. The coarseness of these rock fragments of the tuff decrease to the east and southeast of Rodeo. The Pinole tuff consists essentially of broken fragments of pumice which range in size from small angular pea-size pieces to angular fragments 6 to 8 inches in diameter scattered throughout a matrix of yellowish to grayish pumicite (volcanic ash). It also contains minor proportions of orthoclase, oligoclase-andesine, augite, hypersthene, green and brown hornblende, and rarely zircon. The glass has an average index of refraction of 1.515. Glass with this index of refraction ordinarily is dactitic in composition (George, 1924, p. 365), but a lack of quartz and the presence of both augite and hypersthene suggests an andesitic composition.

The Lawlor and Pinole tuffs are similar lithologically and may be age equivalents (Weaver 1949).

Rock Products

Since 1946 the rock products industry has ranked first in quantity and value among mineral commodities produced in Contra Costa County. The classes of rock products discussed in this section are: (1) broken and crushed stone used primarily for riprap and fill in water-front projects; (2) crushed rock* used mainly as road base; (3) sand and gravel used as bituminous and concrete aggregate; (4) specialty sands including foundry and glass; and (5) dimension stone.

Significant tonnages in all classes except dimension stone, gravel, and glass sand are produced in Contra Costa County. In 1957 the county yielded 2,370,802 short tons of crushed stone and sand valued at $2,922,223.

Commercial production of crushed stone is obtained from the Jurassic-Cretaceous(?) Franciscan group metavolcanic rocks at Mount Diablo (two quarries); Franciscan group graywacke-type sandstone at Castro Point (one quarry); Pliocene Moraga volcanic rocks near Orinda (one quarry); and Tertiary sandstone at Pacheco and Walnut Creek (two quarries). Sand is obtained from sand dunes near Antioch

* In technical usage "stone" is the term applied to material that has been quarried from larger masses of rock, whereas "rock" is applied to material in place before it is broken and cut. In this report, however, the widely accepted usage of the term "crushed rock" is retained for broken and crushed stone that is used primarily for road construction.

Table 7. Geologic formations in Contra Costa County that might be suitable for use as rock products.

Geologic age	Map symbol	Formation	Distribution in county	Suitable rock types	Possible use	Present commercial operations
Recent	Qs	Sand dunes	East-trending ridge along Sacramento River bank	Sand	Paving sand, fill	Morris Sand Co. F. Wills
Pleistocene	Qc	Terrace deposits Montezuma formation	North flank of Los Medanos Hills	Conglomerate lenses	Road base	None
Pliocene	Pv	Moraga formation	Northwest-trending structures along western county; line northeast of Oakland	Volcanic flow rocks: basalt and andesite	Road base, riprap	Tunnel Rock Quarry
	Pc	Mulholland, Wolfskill, and Orinda formations	Northwest-trending belt along western county line north flank of Los Medanos Hills	Conglomerate lenses	Road base	None
Miocene	Mu	San Pablo group: Neroly formation, Cierbo formation, Briones formation	Northwest-trending structures extending from San Pablo bay at Pinole to south of Mt. Diablo	Interbedded massive sandstone and fossiliferous beds	Riprap, road base	Gallagher and Burke (Briones?)
	Mm	Monterey group: Hambre formation, Oursan formation, Sobrante formation	Broad northwest-trending belt extending from San Pablo Bay and Carquinez Strait thru Walnut Creek; along southwest side of Mt. Diablo	Interbedded massive sandstone, and chert and shale	Road base	Serra Bros. (Sobrante ss)
Eocene	E	Undifferentiated Eocene formations	Northwest-trending structures on northeast side of Mt. Diablo from Martinez to Byron and southside of Mt. Diablo	Massive sandstone and conglomerate lenses	Riprap, road base	None
	Ed	Domengine formation	Northwest-trending belt extending from Concord to Byron; northwest flank of Mt. Diablo	Massive sandstone	Glass and foundry sand, road base	Silver Sand Co. Chas. Laws, Marchio
Paleocene	Ep	Martinez formation	Northwest-trending structure vicinity of Martinez	Massive sandstone	Riprap, road base	None
Cretaceous	Ku	Upper Cretaceous formations	Broad belt extending from Mt. Diablo southeast to county line; northwest-trending belt between Crockett and Martinez	Massive sandstone	Riprap, road base	None
	Kl	Lower Cretaceous formations		Shale	Expanded light-weight aggregate	None
Cretaceous-Jurassic	KJf	Franciscan-Knoxville group	North slope of Mt. Diablo, Portrero San Pablo Ridge, west side Berkeley Hills	Massive sandstone	Riprap, road base	Blake Bros.
	KJfv	Franciscan-Knoxville Metavolcanic rocks	Central portion of Mt. Diablo	Greenstone, metabasalt and metadiabase	Riprap, road base	Pacific Cement and Aggregates, Kaiser Co.

(two pits) and from sandstone beds of the Domengine formation (Eocene) near Cowell (two quarries) and Antioch (one quarry). No alluvial gravel is mined in the county.

Broken and Crushed Stone

Broken and crushed stone for use as riprap and fill is produced at only one locality in Contra Costa County, the Blake Bros. quarry in Richmond. Large stone, while always in demand in the San Francisco Bay area, is not readily obtainable in the County.

Riprap consists of irregular fragments of broken stone, which range in weight from 35 tons to less than 100 pounds. They are placed without mortar to provide protection from the erosive action of water. Riprap is used in river and harbor areas and to protect bridge abutments, dams, spillways, and railroad and highway embankments. Stone used as riprap should have a specific gravity greater than 2.5, and a loss of less than 40 percent in the Los Angeles abrasion test. The rock must be sound and durable, free from laminations and weak cleavages and immune to disintegration from the action of water. Any type of rock may be used as long as the physical requirements are met.

Most rock outcrops in Contra Costa County are fractured, soft, thinly bedded or too light to yield stone suitable for riprap. There are few geologic formations in the county from which sound stone may be obtained. The principal formations are the sandstone of the Franciscan group and the volcanic flow rocks of the Moraga formation. Other formations, which might provide small quantities of large stone in local areas where the rock is sufficiently well indurated, free from excessive fractures and of sufficient weight, are summarized in table 7.

Briefly, these include the massive sandstone beds of the San Pablo group of Miocene age (Neroly, Cierbo and Briones formations—particularly the shell reefs of the Briones; (2) the massive sandstone beds of the Markley, Domengine, Meganos and Martinez formations (Eocene); (3) the massive sandstone beds of the undifferentiated Cretaceous formations and the Jurassic-Knoxville group (?), and (4) the metavolcanic rocks of the Franciscan group.

The principal source of broken and crushed stone in the county is a 5 mile long, half- to mile-and-a-half wide, ridge of Franciscan sandstone, called Portero San Pablo, which borders on the bay in the city of Richmond. The usable sandstone beds range in thickness from 8 to 10 feet, dip approximately 50° to the southwest, and strike northwestward. Some thinner sandstone beds are interbedded with minor amounts of shale. No prominent joint system is evident in quarries. This is the same strata from which stone is produced across the bay in Marin County at San Pedro point. In the past, several quarries were worked at various places in the same zone on this ridge (Laizure 1927, Hueguenin and Castello 1920).

Blake Bros. operate the one remaining quarry, near the Richmond-San Rafael bridge, to produce riprap and other sizes of crushed stone. The rock is quarried by using a coyote-hole method of primary blasting. Large blocks of rock are broken up by dynamite charges placed in a small adit driven through the face, with crosscut drifts run back of the quarry face at the level of the quarry floor. The charges are placed in

the crosscuts and part way out in the adit. Adit and crosscuts are then completely backfilled and all charges detonated simultaneously.

Fragments too large to be handled by power shovels are broken by secondary drilling and blasting. Diesel shovels load end-dump trucks which haul to a feeder pit from which the stone is conveyed to a 6-inch grizzly. The plus 6-inch to 250 pound stone is removed and trucked to the rail or barge facilities. Stone over 250 pounds is placed directly on trucks in the quarry by shovels for delivery to the job.

Some large stone, up to 10 tons, is occasionally obtained at the Tunnel Rock Company quarry in the Berkeley Hills near Orinda. The quarry has been opened in the south limb of a syncline in the east-dipping red and black andesite and basalt flows of the Moraga formation. Two-thirds of the rock is free digging, though primary blasting is used occasionally. The quarry is worked in benches 14-25′ high. Drilling is done with wagon drills. The smaller fragmented material is loaded in trucks by power shovel. The larger pieces are pushed aside and broken into smaller fragments by a shovel equipped with a 5 ton drop ball.

Crushed Rock

Crushed rock used as bituminous aggregate, road base, railroad ballast, and fill constituted 90 percent of the stone production for 1955. Most of the crushed rock is used as aggregate base in road construction; only a small portion is used as bituminous or concrete aggregate. The bulk of the materials used for this latter purpose are imported into the county from sand and gravel plants near Niles and Livermore in Alameda County, and Tracy in San Joaquin County. There are few places in the county where sound, hard, durable rock suitable for crushing for use as concrete or bituminous aggregate, crop out.

The county is underlain primarily by soft, weak, thinly bedded sedimentary rocks, chiefly sandstone and shale. In addition to being soft and weak, these rocks ordinarily contain excessive amounts of clay and silt. This prevents the material from meeting the rigid specifications set up for crushed rock used as bituminous and concrete aggregate. However, these rocks do meet the requirements of less demanding specifications for "crusher run base" or untreated base in road construction. Untreated base is the term used by the California Division of Highways to apply to the layer of material that supports the paving surface and which overlies the natural ground surface or a subbase.

To meet more rigid specifications for higher grades of crushed rock, untreated base materials would have to be washed to remove the excessive amounts of clay and silt. Only one operator, Blake Bros., washes crushed Franciscan sandstone which is used as bituminous and concrete aggregate. State specifications for untreated base are as follows:*

1) Gradation: The combined mineral aggregate shall conform to the grading specified for the ¾ inch, maximum aggregate.

Sieve size	*Percentage passing sieve*
1-inch	100
¾-inch	90-100
No. 4	35-55
No. 200	3-9

* From California Division of Highways, Standard Specifications Aug. 1954, p. 92.

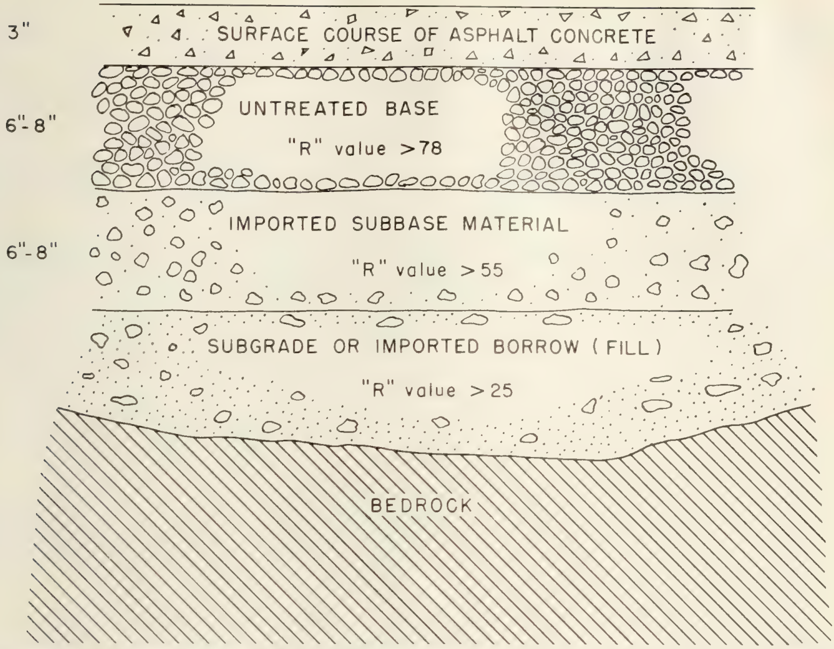

FIGURE 5. Cross section of bituminous pavement in a California State highway (data from California Division of Highways).

2) Quality. The mineral aggregate must perform to the following requirements:

Loss in the Los Angeles abrasion test (500 rev.)	50 percent maximum
Resistance ("R") value	78 minimum
Sand equivalent	30 minimum

The Los Angeles abrasion test is designed to determine the hardness and durability of an aggregate by subjecting it to abrasion in a rotating cylinder containing metal balls. The resistance value test uses a stabilometer to measure the ability of the material to resist plastic deformation under vehicle loads. The higher the clay and silt content the lower the bearing strength and "R" value. The sand equivalent test indicates the relative proportion of detrimental fine dust or claylike material in the aggregate. The higher the sand equivalent, the lower the clay and silt content.

Crushed rock which is too soft or weak to be used as untreated base can often be used in road construction for less exacting purposes such as a subbase and fill beneath the base course. Material for these purposes must meet less rigid specifications which are set up primarily upon the Resistance ("R") value. For subbase (called imported subbase by the state and select import by the County), the "R" value must exceed 55. Crushed rock used as the subgrade (imported base or common fill) requires an "R" value exceeding 25. Figure 5 is a cross section of a typical State Highway construction using bituminous surfacing.

Table 8. Rock products Contra Costa County (active producers, 1957).

CRUSHED AND BROKEN STONE

Operator name and address	Location: Sec.	Location: T.	Location: R.	Location: B and M	History of operations	Geological data	Mining data: Holdings	Mining data: Mining method, equipment and haulage
Blake Bros. Box 1002 Richmond	15, 16 Proj.	1N	5W	MD	Started 1907.	West-dipping (50°) Franciscan sandstone beds 8-10 feet thick, some shale and thin sandstone interbeds. No prominent joint system.	150 acres	Coyote method of blasting. Secondary drilling and blasting of large fragments. Two diesel shovels load Euclid end dump-trucks that haul to riprap plant and crusher run base plant in quarry. Trucks also haul large stone from quarry face to barge; and from riprap plant to old crushing plant a distance of approximately 0.1 mile.
Don Bruce c/o Camp Hearns 1290 Arlington El Cerrito	15 Proj.	1N	4W	MD	Started 1953. Operate in dry weather only.	Serpentine in Franciscan group. Hard, dense, jointed and fractured, many weathered seams present. No definite joint pattern.	Leased from Boy Scouts	D8 caterpillar tractor rips deposit. Front end loader shovels into rear dump truck which hauls 200 feet to portable crusher.
Gallagher and Burke Walnut Creek	26 Proj.	1N	2W	MD	Started 1955.	Thin-bedded, highly jointed, steeply dipping sandstone of San Pablo group (Briones?)	12 acres	Diesel shovel or D8 caterpillar tractor excavate. Rear dump trucks haul several hundred feet to portable crusher.
Henry J. Kaiser-Clayton 1924 Broadway Oakland	NE¼ 22	1N	1W	MD	Started 1955.	Steeply dipping, bedded Franciscan metavolcanic rocks (basalt and diabase). Beds average 3-5 feet in thickness.	Leased from L. Mangini	Deposit worked in 40-50 foot high benches. Joy wagon drills used to drill 4-inch holes 40 feet deep on 8-foot centers. Use 40 percent dynamite. Broken rock moved by D-8 caterpillar tractor to two 2½-cubic yard diesel shovels which load four 18-ton Euclid end dump trucks for 700-foot haul to primary crusher.
Martin Bros. Concord	6 Proj.	1N	1W	MD	Started mid-1956.	Shallow-dipping, soft Eocene sandstones. Soft on surface but harder with depth.	Leased	Surface stripping, rip with tractor.
Pacific Cement and Aggregates Co. Clayton Plant #135 400 Alabama Street San Francisco	NW¼ 23	1N	1W	MD	Formerly Harrison-Birdwell (1947-1953). Started Jan. 1954.	Steeply dipping metavolcanic rocks of Franciscan group. Beds 5-10 feet thick.	Leased from Murchio Bros.	Wagon drills used to drill holes for blasting. Stone loaded by shovel into truck for half mile haul to plant.

Table 8. Rock products Contra Costa County (active producers, 1957).—Continued

Approximate size of excavation	Processing data		Reported capacity	Number of employees	Remarks
	Crushing and classification	Products			
Approx. 1500 feet long by 800 feet wide by 200 feet high.	New plant contains one primary jaw and 2 secondary gyratory crushers, standard mechanical screens; for riprap use either #6 or #12 gyratory crusher to produce 6-inch or 8-inch maximum. Old plant has two #6 gyratory primary and 4 pair secondary gyratory crushers, standard screening devices.	Crusher run base—¾-inch, 1½-inch maximum. Riprap, 6-inch—250 pounds. 1-3 tons, up to 1200 tons maximum. Nine sizes of crushed rock, 2½-inch maximum, for use as concrete and bituminous aggregate.	4,000 tons per day	Average 77	Use some Antioch dune sand. Have facilities at old plant to load barges from conveyors, own barges and ready-mix trucks. Concrete batch plant and asphalt plant on premises.
Approx. 100 feet long by 50 feet wide by 75 feet high.	Portable crushing plant powered by 25 h.p. diesel engine; 12-inch grizzly. 18-inch × 12-inch jaw crusher. Wooden loading bunker.	Crusher run base 1½-inch maximum.	100 tons per day	4	No blasting permitted, operate intermittently. Sell only to cities within 1-2 mile haul radius for use as subbase on streets and housing tracts.
100 feet long by 100 feet wide by 15 feet high.	Portable crushing equipment brought in when needed.	Unclassified fill, imported subbase for state roads.	1800 tons per day	5	Intermittent operation. Sell to outsiders but use most of material themselves. Has "R" value of 60-70.
750 feet long by 1000 feet wide by 150 feet high.	Primary 36×48-inch jaw, 2 secondary gyratory crushers—(Symons 5½-foot shorthead and 4¼-foot standard cone). Mechanical vibrating screens. No washing.	Crusher run base ¾-inch, 1½-inch max. 2½-inch×1½-inch 1½-inch×¾-inch ¾-inch×½-inch ½-inch×¼-inch ¼-inch to dust.	400 tons per hour	26	Twenty-five feet of overburden stripped off. Sell all products to outsiders.
800 feet long by 400 feet wide surface area.	No plant.	Imported borrow (fill).			Use most of material themselves as fill, some used by county as imported select base.
500 feet long by 250 feet wide by 350 feet high.	Primary Cedar Rapids jaw; 2 Telesmith gyratory, 16-inch×36-inch Allis gyratory, secondary crushers; Symons 3-foot cone and 16-inch×30-inch tertiary roll crushers. Mechanical vibrating screens. No washing.	Crusher run base—2½-inch×1½-inch 1½-inch×¾-inch ¾-inch×½-inch ½-inch×¼-inch ¼-inch to dust. Drain rock.	2400 tons per day	Average 24	Use material in own asphalt plant and sell to everyone at quarry.

Table 8. Rock products Contra Costa County (active producers, 1957).—Continued

CRUSHED AND BROKEN STONE

Operator name and address	Location Sec.	T.	R.	B and M	History of operations	Geological data	Mining data Holdings	Mining method, equipment and haulage
Serra Bros. Route 1, Box 335 Martinez	34 Proj.	2N	2W	MD	Quarry intermittently active since 1906. Present operators active since 1940.	Soft, fossiliferous sandstone of Miocene Sobrante formation, strikes northwest and dips about 70° S. Beds 3-10 feet thick.	Leased from C. Slater	Slight blasting required. Rip with D8 caterpillar tractor. Load trucks with ¾ yard shovel, haul 0.1 mile to plant.
Tunnel Rock Quarry A. C. Goerig 220 Tunnel Road Orinda	SW¼ 9	1S	3W	MD	Started 1951 on contractual basis, owner-operated since 1952.	Steeply dipping bedded volcanic flow rocks in Miocene Moraga formation. Beds 3-10 feet thick dip about 80° on south limb of syncline.	350 acres	Wagon drill used for holes for blasting. Worked in 14-25 foot high benches. One 1½-yard and a one-yard diesel shovel load end dump trucks that haul few hundred feet to plant.

SAND

Operator Name and address	Location Sec.	T.	R.	B and M	History of operation	Geological data	Holdings	Quarry data Excavating, equipment and hauling
Contra Costa County	SW¼ 1	1S	2E	MD		Fine-grained, uncemented uniform, white sandstone of Domengine formation, that strikes northwest and dips 30° NE.	Leased from Longwell Ranch	Bulldoze and shovel sand into trucks.
Charles Laws 585 Risdon Rd. Concord	8 Proj.	1N	1W	MD	Started 1947	Weakly consolidated sandstone of Domengine formation; strikes west and dips 35° N.	Leased from Cowell	Bulldozer rips sand; front end loader fills 15-yard truck.
Marchio Sand Co. Oil Canyon Road Antioch	SE¼ 11	1N	1E	MD	Started 1947.	Crudely stratified, semi-indurated Domengine sandstone that strikes N.50°W and dips 25° NE.	Leased from L. Ginochio	Drill and shoot, shovel into truck to haul to plant.
Morris Sand Co. Rt. 1, Box 100 Antioch	SE¼ 18	2N	2E	MD	Started 1921.	Compacted, unindurated, unstratified, Recent alluvial dune sand. Upper portion of deposit has less fines and is more suitable.	Leased from George Stamm	Skip loader digs and loads trucks and railroad cars of 70 ton capacity.

Table 8. Rock products Contra Costa (active producers, 1957).—Continued

Approximate size of excavation	Processing data		Reported capacity	Number of employees	Remarks
	Crushing and classification	Products			
75 feet long by 150 feet wide by 50 feet high.	15-inch×38-inch Pacific jaw crusher, and roll crusher.	Cement-treated base, fill, imported borrow.	100 tons per hour	Average 3	Rock too soft for crusher run base, some harder rock may be obtained by selective excavation. Boulders 3×5 feet are obtainable.
150 feet long by 100 feet wide by 12 feet high.	Primary 25-inch×40-inch Cedar Rapids jaw; secondary 15-inch×38-inch Wheeling jaw crusher; tertiary roll crushers—30-inch×42-inch Pioneer and 9-inch×38-inch Pacific.	Riprap up to 10 ton stone; crusher run base—$\frac{3}{4}$-inch, $1\frac{1}{2}$-inch max. Drain rock.	150 tons per day	15	Two-thirds of deposit is free-digging. Some clay present in seams. Use selective quarrying. Sell to everyone at quarry.

Approximate size of excavations	Plant processing data		Reported capacity	Number of employees	Remarks
	Crushing and classification	Products			
Working face 40 feet high by 200 feet long	Portable crushing equipment used when needed.	Imported borrow.			Intermittently quarried as local source of materials in county road construction.
Working face 25 feet high by 75 feet long.	No plant	Fill sand for asbestos shingle.	45 cubic yards per day	1	Sand trucked to Johns Manville, Pittsburg plant. In same pit as Silver Sand Co.
80 feet high by 150 feet long by 50 feet deep.	Rotary scrubber and 8 mesh classifier, sand drag, conveyor to elevated bins.	Foundry sand.		3	Output to Columbia Steel, Pittsburg. Rock quarried intermittently. Stockpiled at processing plant.
30 feet high by 200 feet long by 100 feet deep.	No plant.	Bituminous mix, blend sand in concrete.	175 tons per hour	1	Sells to hot mix plants in San Francisco area. Sells directly to hot batch plant of Antioch Construction Co. on premises. Competition from materials from Tracy caused decline in use of Antioch dune sand.

Table 8. Rock products Contra Costa (active producers, 1957).—Continued

SAND

Name and address	Location: Sec.	T.	R.	B and M	History of operation	Geological data	Holdings	Quarry data: Excavating, equipment and hauling
Silver Sand Co. J. Nelson P. O. Box 5 Cowell	8 Proj.	1N	1W	MD	Started 1953.	Weakly consolidated white, unindurated, compacted sandstone of Eocene Domengine formation that strikes west and dips 35° N. Deposit is approximately 1000 feet wide, 90 feet deep, 400 feet long.	Leased from Cowell	Use bulldozer (D7) to rip sand and load to trommel screen. Bulldozer shovels sand into hopper and washing equipment. Slurry transported through pipe to washing plant.
Silver Sand Co. Nortonville	SE¼ 5	1N	1E	MD	Started 1957.	Weakly consolidated sandstone of Domengine formation in section of interbedded sandstone and shale that strikes west and dips 25° N. Overlies coal bed.	Leased from Southport Land & Comm. Co. 1600 acres	Dozer to loading ramp, truck to Cowell plant.
Wills, F. Route 1, Box 101 Antioch	SW¼ 17	2N	2E	MD	Started prior to 1951.	Unstratified Recent alluvial dune sand.	Leased from J. Little	Bucket loader or crane loads into trucks. Use bulldozer to feed crane.

Geology of Deposits. In Contra Costa County, crushed rock is produced from a number of geologic formations. Commercial production is obtained from the volcanic flow rocks of the Moraga formation (Pliocene) in the Berkeley Hills; sandstone of the San Pablo group (Miocene) near Walnut Creek; sandstone of the Miocene Monterey group (Sobrante sandstone) near Pacheco; graywacke-type sandstone of the Franciscan group (Jurassic-Cretaceous) at Castro Point, Richmond; and metavolcanic rocks of the Franciscan group at Mt. Diablo near Clayton. The distribution of these formations is indicated on the geologic map and is summarized in table 7.

In addition to these formations which yield suitable crushed rock, there are other less desirable formations from which intermittent production is obtained. Pits in the latter formations are generally worked by contractors or by Contra Costa County to supply the lower grades of materials such as imported sub-base or imported borrow (common fill) for road construction. The soft sandstones of formations such as the Orinda, Martinez, Domengine are used for these purposes.

Other formations which may be locally suitable for use as road base are listed on table 7. Included in this group are the conglomerate lenses in the Montezuma, Mulholland and Orinda formations; massive sandstones and shell reefs of the San Pablo and Monterey groups; massive sandstones of the Markley, Domengine, Meganos and Martinez formations, and the massive sandstones of the undifferentiated Cretaceous formations and the Knoxville group. These lithologic units are generally unsuitable under present specifications, but if examined in

Table 8. Rock products Contra Costa (active producers, 1957).—Continued

Approximate size of excavations	Plant processing data: Crushing and classification	Plant processing data: Products	Reported capacity	Number of employees	Remarks
40 feet high by 1000 feet long	Revolving trommel set at ⅛-inch. Setting up washing plant (4/57) with Krebs cyclone, sand screw classifier, settling pond, radial stacker.	Bituminous sand, unclassified fill, imported subbase. Washed sand to be used as concrete and foundry sand.	500 tons per day	3	Pipes water from canal, intends to produce foundry, concrete, and plaster sand after wash plant completed.
		To be blended with Cowell sand for use as foundry sand after washing.			
Small dunes 25-30 feet high.	No plant.	Fill sand, imported subbase.	90 yards per day	2-3	Intermittent operation. Use themselves or sell to outsiders at pit. Sand delivered in trucks to job site. Not used in bituminous mix.

detail in small local areas, some portions may be indurated or massive enough to be usable.

Operations. Crushed rock operations are comparatively well standardized. The rock is drilled and blasted or ripped by bulldozers and

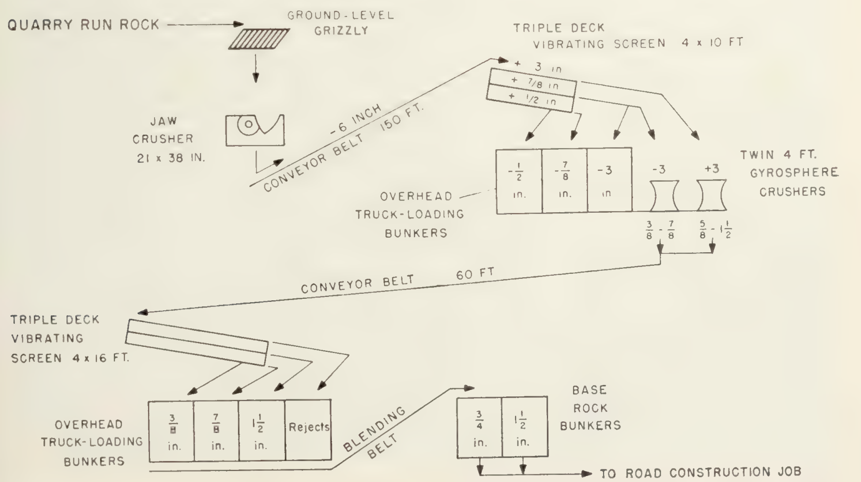

FIGURE 6. Generalized flow sheet of new crushed rock plant, Blake Bros., Richmond.

rippers and loaded onto trucks for conveyance to the crushing plants. Blake Bros. uses the coyote hole method of blasting which brings down enough material to process for several months. The other operators quarry in benches using wagon drills to bore holes for blasting.

The typical plant consists of a number of crushers and screens designed to produce particles of specified sizes. Ordinarily the primary crushing is done by jaw crusher, secondary crushing by a gyratory crusher, and tertiary crushing either by a gyratory or by a roll crusher. The crushing plants range in size from portable crushing units capable of producing 25 tons an hour, to stationary plants using three or four jaw or gyratory crushers capable of producing 400 tons an hour. Data on the crushed rock operations active in 1957 are presented in table 8.

Some pits are used only when materials are needed locally. Portable crushing equipment is brought in by the county or by contractors and operated until the required amount of rock is quarried and then the equipment is moved to a new location. Blasting is rarely necessary and tractors equipped with ripping teeth loosen the rock sufficiently so it can be shoveled into trucks for delivery to the job.

Sand and Gravel

Contra Costa County is unique in that it lacks stream deposits of sand and gravel capable of exploitation for use as concrete or bituminous aggregate. In the past, substantial tonnages of sand were produced from Recent sand dunes at Antioch. Competition from sand and gravel

PHOTO 3. Blake Brothers quarry at Point Richmond.

plants near Tracy and Livermore has gradually caused decline in the use of Antioch sand and in 1957, only two operators were actively mining the sand.

The dunes occur in a narrow strip about 800 feet wide extending along the southern shore of the San Joaquin River for a distance of about 2 miles. The original elevation of the dunes ranged from 65 to 115 feet but continued mining for over 30 years has reduced their height to 50 to 80 feet. The sand is fine, yellow-brown, angular and unconsolidated. A screen analysis of a sample of dune sand is presented in table 9.

Table 9. Screen analysis of Antioch dune sand.

Screen size	Percentage passing
30	95
50	86
100	47
200	17

Specialty Sand

Significant tonnages of foundry and glass sand have been obtained from a number of localities in Contra Costa County. From the early 1920's to 1949, approximately 1,300,000 tons of specialty sand valued at over $5,100,000 were produced. One-third of this total was foundry sand, the remainder glass sand. The bulk of production came from two localities, the Nortonville-Somersville area and the Brentwood area, with output divided about equally between them.

Production of glass sand ended in the county in 1945 when the Pittsburg Sand Co. ceased operations at Somersville. Foundry sand has been continuously produced and in 1957 one operator (Marchio Sand Co., located south of Antioch) was still active. The Silver Sand Co., is attempting to synthesize a foundry sand by blending sands mined at Cowell and Nortonville. Sand is also being mined at Cowell for use in asbestos shingles.

Geology of Deposits. All the specialty sands have been obtained from sandstone beds of the Domengine formation (middle Eocene) which crop out to the northeast of Mt. Diablo in a mile wide belt extending from Concord to Byron, a distance of 20 miles. The Domengine formation also crops out as a faulted syncline on the northwest flank of Mt. Diablo near Cowell. Northeast of Mt. Diablo the formation comprises 1000 feet of interbedded shale and sandstone that generally strike to the northwest and dip from 25° to 40° to the north.

Commercial production is obtained from a white sandstone member that ranges in thickness from 75 to 400 feet. This sandstone is massive, compact, and relatively uncemented, containing angular, well-sorted medium-sized grains of quartz (80-90%) and feldspar (10-20%). Mechanical analyses of sands from the Domengine formation are presented in table 10.

Nortonville-Somersville District. The sandstone in this area is massive and weakly indurated, and is found in beds 25 to 30 feet thick separated by several tens of feet of shale in a section of sandstone and shale that strike west and dip 25° north. The deposit at Nortonville

Table 10. Mechanical analyses of sand from Domengine formation (from Wright, L. A., 1944, pp. 66, 69).

Location of sample	Percent retained on screens									
SCREEN SIZE	12	20	30	40	50	70	100	140	200	—200
Silver Sand Co. Cowell, Pit run			1	3	14	28	21	10	5	3
washed			0.3	4.9	36.9	28.3	13.0		12.3	4.36
Roberts Sand Co. Pit—Nortonville—washed		2.3	8.8	15.0	22.8	25.2	18.6	4.5	1.0	0.7
Marchio Sand Co.—Medium-washed		0.4		25.8	19.1	16.2	17.5	11.0	4.0	5.2
Fine-washed		0.8		6.0	6.4	17.2	35.4	23.0	6.0	4.5
Nortonville— 1 crude			1.1	10.1	38.6	25.9	9.8	4.6	2.7	7.2
1 washed			1.3	10.9	40.8	30.3	11.7	3.9	0.7	0.2
11 crude	0.2	1.9	17.4	30.4	16.5	11.1	7.5	4.5	3.1	7.3
11 washed		2.5	23.6	33.9	19.5	11.6	7.2	2.9	0.7	
Somersville— 1 crude		1.1	9.0	19.3	25.8	23.8	9.8	4.1	2.1	4.8
1 washed		1.0	8.9	22.2	27.2	27.2	9.5	2.9	0.6	0.3
11 crude		0.2	1.6	5.0	20.4	38.6	19.4	6.4	3.0	5.5
11 washed			1.6	3.0	18.7	44.0	23.8	6.7	2.2	
111 crude			1.2	3.1	15.3	33.0	27.2	9.8	3.8	6.6
111 washed			0.7	4.0	18.0	34.4	28.8	10.6	2.5	1.0

PHOTO 4. Sand bunkers, waste dump, and shale outcrops near Black Diamond mine.

was first worked for sand in 1925 by The Columbia Steel Co. Foundry sand was produced from sandstones overlying a coal bed in the Black Diamond coal mine. A room and pillar method of mining was used. The Columbia Steel Co. operated the deposit until 1930 and was succeeded by Roberts (et al.) who operated intermittently until 1949, producing foundry sand.

Glass sand was quarried from 1932 to 1945 at the Pittsburg coal mine, Somersville, by the Hazel-Atlas Glass Co. and its subsidiary, the Pittsburg Sand Co. (since 1937). At Somersville, the sandstone is composed of 85-90 percent quartz and 10-15 percent soda plagioclase. The sand has a silica content of over 92 percent as shown by the chemical analysis made by Galliher (1932).

SiO_2	93.80 percent
Al_2O_3	3.52 percent
Fe_2O_3	0.08 percent
Ignition loss	2.30 percent
	99.70 percent

Accessory minerals include hypersthene, zircon, ilmenite, tourmaline, kyanite, garnet, rutile, and beryl. Most of these materials contain iron in traces but all may be removed by concentrating tables according to Galliher (1932).

In 1957 the Silver Sand Co. was stripping sand from the old Roberts pit with a bulldozer. Trucks (loaded by means of a ramp) hauled sand to the company plant at Cowell where it was washed and blended with Cowell sand in an attempt to produce a foundry grade product.

Antioch-Marchio District. About 3 miles east of Nortonville at the old Star coal mine, the Marchio Sand Co., is operating a quarry in the same geologic formation. Here, the sandstone is crudely stratified with a total thickness of 80 feet, striking north 50° west and dipping 25° northeastward. The sandstone is predominantly white but locally iron-stained adjacent to fractures or parallel to the bedding. The rock is blasted and shoveled onto trucks for haulage to the plant.

At the processing plant, the weakly consolidated sandstone is crushed beneath a tractor. The sand is fed with water to a rotary scrubber and classifier, removed by a sand drag onto a conveyor belt and elevated to storage bins. This sand, which contains 95 percent silica, is used by Columbia Steel Co., for foundry purposes.

Brentwood District. Near Brentwood, about 7 miles to the southeast of the Marchio quarry, the same belt of Domengine sandstone was worked for foundry and glass sand from 1920-1942. The deposits here consist of fine-grained, uniform, white sandstones that strike northwestward and dip 30° northeast. The quartz-rich sandstones are exposed for several thousand feet along the strike; their depth along the dip is unknown.

The sand was screened and washed free of clay and leached with chemicals to reduce the iron content to 0.045 percent for use in glass manufacturing.

Depletion of easily accessible near-surface reserves contributed to the cessation of mining operations. Chemical analyses of the Brentwood sand made by Galliher (1932) are presented in table 11.

Table 11. Chemical analyses of Brentwood (Domengine) sand.

	Unwashed		Washed
SiO_2	96.50%	95.54%	97.02%
Al_2O_3	1.30	2.19	1.20
Fe_2O_3	0.22	0.21	0.22
CaO	0.35	0.20	0.30
MgO	0.36	0.29	0.33
Alkalies	--	0.41	0.20
Ignition loss	0.32	--	--
	99.05%	98.84%	99.27%

Cowell District. The Domengine sandstone is being worked by the Silver Sand Co. near Cowell. Here the sandstone crops out in massive beds about 20 feet thick that strike west and dip 35° north. The deposit is approximately 1000 feet wide, 90 feet deep and 400 feet long and comprises unindurated, compacted, white to buff-colored (where iron stained) sandstones.

Open pit mining methods are used wherein a tractor rips the soft sandstone and bulldozes the loose material into a revolving trommel which removes the plus $\frac{1}{8}$-inch grains in summer and plus $\frac{1}{4}$-inch grains in winter. This oversize is sold as fill while the undersize is sold for use in concrete and bituminous mix or as select import for county road construction. The capacity of the trommel is 500 tons per day.

In April 1957, a washing plant designed to produce foundry, concrete and plaster sand was under construction. The flow of material was planned as follows: At the pit a bulldozer moves sand into a hopper that feeds washing equipment. The wet slurry is transported through a steel pipe to a Krebs cyclone (to remove silt and clay and recover the fine sand), then to a sand screw and a radial stacker. A concrete settling pond collects the wash water and reclaims the clay. Water is piped from a canal nearby.

The present operator started here in 1953 although the sand was quarried in the past by the Henry Cowell Lime and Cement Co., for use in cement; and by other operators as fill sand.

In another portion of the pit used by the Silver Sand Co., Chas. Laws uses a bulldozer to loosen the sand which he loads by a front-end loader into a truck for haul to Pittsburg. Laws has been hauling sand since 1947 to the Johns-Manville Company for use in asphalt shingles. Processing is done at the company plant.

Dimension Stone

Sandstone was quarried from the Martinez formation (Eocene) before the turn of the century for use as building stone. In 1894 a production of 20,000 cubic feet valued at $7,500 was reported.

Stone used in the buildings in the city of Martinez and in the Napa State Hospital was obtained from two quarries near Martinez; the Franklin sandstone quarry, located 3½ miles southwest of Martinez in Franklin canyon and the Martinez quarry located three quarters of a mile southwest of that city. The sandstone occurs in beds ranging from 8-to-25 feet in thickness which strike northwest and dip about 45° northeastward. The stone is blue-gray; it is soft when quarried but hardens upon exposure.

Paving blocks reportedly were produced prior to 1890 at small quarries in the hills between Concord and Clayton—about 6 miles northwest of Mt. Diablo presumably from the metavolcanic rocks of the Franciscan group.

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TABULATION OF CONTRA COSTA COUNTY MINERAL DEPOSITS

The list of mineral deposits is arranged alphabetically by commodities. Under each commodity heading the mineral deposits are listed alphabetically by deposit names. A separate list of natural gas wells is presented in table 5, and a list of unproductive wells (dry holes or wildcat wells) will be found in table 6. The term "proj." (for projected) indicates that the area has not been included in the public land survey, but that we have projected the land lines in order to assist in locating the deposits.

In the "Remarks" column "R" means "Report" and "B" means "Bulletin" of the California Division of Mines. The number before the colon indicates the report or bulletin number, that after the colon indicates the page number. Where an author's name is cited, the complete reference will be found in the bibliography accompanying this report. The first number after the name is the date shown in the bibliography, abbreviated; the number following the colon is the page reference.

CHROMITE

Map No.	Claim, mine, or group	Owner name, address	Location: Sec.	T.	R.	B & M	Remarks
	Mt. Zion chrome claim	Mt. Diablo Development Co. (pre-1927)		1N	1E	MD	Development work; no record of production. (B 134 (pt. 2, ch. 2):52; R 27:12.)

CLAY

Map No.	Claim, mine, or group	Owner name, address	Location: Sec.	T.	R.	B & M	Remarks
	American Radiator and Standard Sanitary Manufacturing Corp. (Standard Sanitary Manufacturing Co.; Pacific Sanitary Manufacturing Co.; Pacific Pottery; Pacific Enamel Works)	American Radiator and Standard Sanitary Manufacturing Corp., 55 New Montgomery St., San Francisco					Manufactures porcelain and enameled sanitary ware from crude products from out-of-state. Plants at Richmond and San Pablo established by predecessor companies and expanded. Active. (R 17:49; B 99:75.)
	Carquinez Brick and Tile Co.						Brick plant at Eckley near Port Costa. Operated pre-1914. Plant removed in 1918. (R 17:49.)
	Coast Firebrick Co.						Plant built at Richmond in 1919 to manufacture fire brick and clay products (R 17:49; PR 7:44.)
	California Art Tile Co.						See California Ceramic and Quarry Tile Co.
	California Ceramic and Quarry Tile Co.	California Ceramic and Quarry Tile Co., 27th and Main Sts., Richmond					Plant built in 1922; rebuilt and expanded in 1926. Lincoln clay and Ione sand used to make wall tile. Mix is dry-panned, pug-milled, augered, dried and fired in four round down-draft kilns. (R 23:7; B 99:72.)
	Diamond Brick Co.						Plant built at Pittsburg in 1915 for manufacturing of common red brick; plant partly dismantled by 1920. (R 17:49; PR 7:44.)
	Gerlack Brick Co.						(R 23:9.)

	Gladding, McBean & Co. (Stockton Firebrick Co.)	Gladding, McBean and Co., 9th and Harrison Sts., San Francisco					Plant at Pittsburg established by predecessor company in 1931. Uses Ione and Lincoln fire clays to produce refractory brick by stiff-mud, dry-press and hand-mold processes. Capacity 5000 tons of burned product per month. Active. (R 47:603.)
	Golden Gate Sandstone Brick Co.						Plant made a limed brick in 1904. (B 38:166.)
	Holland Sandstone Brick Co.						Plant 1 mile east of Antioch, north of Santa Fe RR, established in 1903. Made limed brick. Not operating in 1904. Operated a sand plant in 1919. (B 38:166; R 17:61.)
	Los Angeles Pressed Brick Co.						See United Materials and Richmond Pressed Brick Co.
	Mt. Diablo Pottery and Paving Brick Co.						Plant opened about 1896, one mile south of Antioch on Southern Pacific RR. Operated about 1 year, using clay from the coal mines near Stewartsville. (R 13:614; B 38:212.)
	Mastercraft Tile and Roofing Co.						Plant on San Pablo Canyon Road near San Pablo. Clay for hand-molded roofing tile obtained near Richmond during 1926. (R 23:7.)
	N. Clark & Sons		26	1N	2W	MD (proj)	Deposit of soft, white, thin-bedded, calcareous Pinole tuff, used in Alameda plant. Pit at Oxley siding, ½ mile north of Walnut Creek. (R 17:49; B 99:73.) See Gallagher & Burke Inc., under Rock Products.
	Pacific Sanitary Manufacturing Co.						See American Radiator and Standard Sanitary Manufacturing Company.
1	Port Costa Brick Works	Port Costa Brick Works, 6th and Berry Sts., San Francisco	10	2N	3W	MD (proj)	Plant established at Port Costa in 1905. Local clay shale of Cretaceous age is blended with Lincoln clay and made into brick by stiff mud process. Daily capacity 90,000 bricks. Active. (R 17:50; 23:8; 47:572; herein.)
	Richmond Pressed Brick Co.						See United Materials and Richmond Pressed Brick Co.

CLAY—Continued

Map No.	Claim, mine, or group	Owner name, address	Location Sec.	T.	R.	B & M	Remarks
	Standard Sanitary Manufacturing Co.	----------	----------	----------	----------	----------	See American Radiator and Standard Sanitary Manufacturing Co.
	Stockton Firebrick Co.----------	----------	----------	----------	----------	----------	See Gladding, McBean & Co.
	Technical Porcelain and Chinaware Co.	Technical Porcelain and Chinaware Co., 6416 Manila Ave., El Cerrito	----------	----------	----------	----------	Vitrified whiteware manufactured from Georgia ball clay and Kentucky china clay in El Cerrito. Active.
2	United Materials and Richmond Pressed Brick Co. (Richmond Pressed Brick Co., Los Angeles Pressed Brick Co.)	United Materials and Richmond Pressed Brick Co., Ltd., Box 7, Point Richmond	23	1N	5W	MD (proj)	Plant established at Point Richmond in 1907 by predecessor company. Clay shale of Franciscan formation blended with Lincoln and Ione clay to produce brick products by stiff-mud process. Capacity 40,000 face bricks per day. Active. (R 17:51; 23:9; 47:573; B 99:74; herein.)

COAL

Map No.	Claim, mine, or group	Owner name, address	Sec.	T.	R.	B & M	Remarks
3	Black Diamond (Nortonville; Union; Manhattan; Peacock; Cumberland; Mt. Hope)	Southport Land and Commercial Co., 220 Montgomery St., San Francisco	4, 5, 8, 9	1N	1E	MD	In 1877 Clark bed developed by two inclined shafts and a 415-foot vertical shaft. Two drifts off the inclined shafts were each more than a mile long. Extensive workings on the Black Diamond bed. Total production 1861-85 was 1,402,215 long tons. Coal mining ceased in 1885. In 1905 the mine was reopened to supply coal to a briquetting plant at Los Medanos. Later, the plant burned and the mine was closed. Token production in 1915-17, 1928, 1939-40. Intermittent foundry sand production 1922-45. (Goodyear 87:128-156; Lord 13:395.)
	Brentwood----------	----------	----------	1N	1E	MD	See Pacific. A general term applied to mines and prospects on Rancho Los Medanos.

4	Central (Stewart's)	L. R. and M. Ginochio (?), 123 Beede Way, Antioch	ctr 10	1N	1E	MD	Originally opened by 1030-foot level tunnel driven north to Clark bed. Encountered four coal seams below Clark bed. Drift driven 275 feet east and 375 feet west on Clark bed, which averaged 39 inches in thickness, dipped 28° N. Numerous small faults where coal was crushed and soft. Breast-stoped 450 feet up dip. Some work also done on Black Diamond bed; coal was soft and bony. Record of 61,189 long tons of coal produced from 1867-76. Worked again in 1893; 32 men employed in 1895 and coal shipped to Antioch via narrow gauge railroad. (Goodyear 87:141, 142, 156; Crawford 94:48, 141.)
	Cumberland			1N	1E	MD	See Black Diamond. An early name for part of the Black Diamond holdings.
5	Empire	L. & E. Higgins, RFD 1, Box 1175, Antioch	12	1N	1E	MD	Inclined shaft sunk 200 feet on outcropping bed 1860-61; work stopped by influx of water. Shaft extended to 600 feet in 1875 and drifts run 300 feet west and 400 feet east on a 4-foot bed of coal (Clark bed?). Production over 3000 long tons coal in 1876. Intermittent production until 1896, when mine was closed permanently.
	Eureka		SE¼ 4	1N	1E	MD	Clark bed mined up dip from drift to outcrop a distance of 500 to 600 feet; also mined down dip to Independent workings. Some production also from Little bed in western part of mine. Produced 100,405 long tons of coal, 1866-73. Ultimately became part of Pittsburg mine. (Goodyear 87:121, 132.)
	Independent		SE¼ 4	1N	1E	MD	Worked Clark bed 400 feet up dip from drift at foot of vertical shaft. Coal production 1866-67 totaled 30,016 long tons. Ultimately became part of Pittsburg mine. (Goodyear 88:123, 126.)
	Israel		N¼ 18	1N	2E	MD	In 1859 coal discovered in cleaning out a spring. Inclined shaft sunk 200 feet (?) on bed dipping 26° N. (underlying Clark bed). Rooms opened on 3-foot bed, some shipments may have been made. Abandoned 1861. (MSP 76:58; Goodyear 87:144.)

COAL—Continued

Map No.	Claim, mine, or group	Owner name, address	Location Sec.	T.	R.	B & M	Remarks
	Manhattan		NW¼ 9	1N	1E	MD	See Black Diamond. Started on outcrop of Clark bed and drove a drift westward 2500 feet. Production of 65 long tons reported in 1866. Property sold to Black Diamond Company. (Goodyear 87:125.)
	Mt. Hope			1N	1E	MD	See Black Diamond. Part of the Black Diamond mine.
6	Pacific (Brentwood)	I. S. Pombo, Rt. 3, Box 750, Tracy	SE¼ 22	1N	2E	MD (proj.)	An 80-foot shaft encountered four coal seams. A second shaft sunk 380 feet to a 7-foot bed drift driven west 275 feet in 1868. Little coal mined; much water handled. (Goodyear 87:145, 146.)
	Peacock	Southport Land and Commercial Co., 220 Montgomery St., San Francisco	NW¼ 8	1N	1E	MD	West of Black Diamond mine. Inclined shaft sunk and tunnel driven 800-900 feet to Black Diamond bed. Two other coal seams encountered. Ground was badly broken and coal was soft. Beds strike west and dip 45° N. No record of production. Abandoned before 1868. Now part of Black Diamond property. (Goodyear 87:140.)
7	Pittsburg (Eureka, Independent, Somersville)	Southern Pacific Co., 65 Market St., San Francisco	SE¼ 4	1N	1E	MD	Clark bed worked 600 to 1000 feet up dip from drift at foot of inclined shaft. Also worked down dip, possibly 800 feet. Extensive workings on Black Diamond bed. Davis inclined shaft sunk about 1892 and coal mined from three beds. Employed 80 men in 1895 and produced 1000 tons per month from Black Diamond bed. Coal shipped from mine to Pittsburg via narrow gauge railroad. Worked continuously until 1902 when mine was permanently closed. Total production is estimated as over 1,000,000 long tons. Intermittent sand production 1932-45. (Goodyear 87:121-131; Irelan 88:160; Goodyear 90:165; Watts 92:192; Crawford 94:144.)

	San Francisco		NW¼ 7(?)	1N	1E	MD	West of Peacock mine. Inclined shaft sunk 300 feet drift driven 275 feet west and 75 feet east, probably on Black Diamond bed. Numerous small faults, coal soft and friable. Did not pay to mine. Abandoned before 1869. (Goodyear 87:140.)
8	Star	L. R. & M. Ginochio, 123 Beede Way, Antioch	SE¼ 11	1N	1E	MD	Considerable coal extracted from Little bed. Was producing in 1893. (Crawford 94:45.)
9	Teutonia	N. & B. Gursky, Rt. Box 92, Brentwood	SW¼ 7	1N	2E	MD	Inclined shaft sunk 400 feet on coal bed dipping 26° N. Drift driven 100 feet east; bed faulted to west. Bed was 3 feet thick, not hard, bony; underlay Clark bed. (Goodyear 87:144.)
	Union		SW¼ 4	1N	1E	MD	See Black Diamond. Clark bed developed by inclined shaft and three drifts. Some production also made from Little bed in eastern part of mine. Produced 250,726 long tons coal 1865-76. Mine closed in December 1876. Property later sold to Black Diamond Company. (Goodyear 87:122, 125, 129.)
	West Hartley	L. & E. Higgins, RFD 1, Box 1175, Antioch	12	1N	1E	MD	West of Empire mine. Inclined shaft sunk 450 (?) feet. Both Clark and Little beds worked. (Goodyear 90:165.)

DIATOMITE

	Dohrman	J. Brazil, P.O. Box 188, Pinole	21	2N	4W	MD	About 1 mile west of Pinole. (R 23:15.)
10	Pawsey	W. H. Hall, Rt. 1, Box 126A, Oroville	22(?)	2N	4W	MD (proj.)	On west edge of Pinole. Quarried from hilltop north of highway for use as road fill. (R23:15.)

LIMESTONE

Map No.	Claim, mine, or group	Owner name, address	Location Sec.	T.	R.	B & M	Remarks
	Coates			1N	1E	MD	In Oil Canyon, 7 miles southwest of Antioch. Adjoins Harkinson deposit. Small production (?). R 12:380; B 38:66.)
11	Cowell (Henry Cowell Lime and Cement Co.; Henry Cowell Lime Co.; Spreckels Sugar Company)	Henry Cowell Lime and Cement Co., 2 Market St., San Francisco	8, 9, 17, 20	1N	1W	MD (proj)	Discontinuous masses of travertine crop out over a considerable area on Lime Ridge. Stone is white, buff or pale blue in color. Used in pre-1900 era for manufacture of lime. Quarried 1908-46 for manufacture of cement. Idle. (B 38:66; R 17:55; 23:15; 43:220; 47:567, 574.)
	Harkinson			1N	1E	MD	In Oil Canyon, 7 miles southwest of Antioch. Compact, amorphous, bluish-gray, fossiliferous limestone. Small shipment (?). Idle (B 38:67.)
	Hopper, L. C.						Leased Mt. Diablo Lime Marl Co. deposit and plant in September 1926. (R 27:16.)
	Mt. Diablo Lime Marl Co.		7 (?)	1N	1E	MD (proj)	Produced crushed limestone for agricultural use from deposit 5 miles northeast of Walnut Creek, 1924-27. (R 27:15.)
	Spreckels		17, 20	1N	1E	MD (proj)	See Cowell.
	Unnamed		15	1S	3W	MD	Fresh-water limestone lens outcrop, about half a mile long and 500 feet wide along contact between Siesta and Moraga formations of Pliocene age. (R 43:221.)
	Unnamed	L. R. & M. Ginochio (?), 123 Beede Way, Antioch	7	1N	1W	MD	Three pits on west side of Lime Ridge. Extend from Treat Lane northwestward for ¾ mile.

MANGANESE

12	Red Rock Island	Mrs. Christine Rogers, 730 El Camino Real, Belmont	17	1N	5W	MD (proj)	Thin layers of psilomelane interbedded with red radiolarian chert. Reported 200 tons ore produced in 1867. (R 23:16; B 125:76; B 152:50.)

MERCURY (QUICKSILVER)

13	Mt. Diablo (Ryne, Rhyne)	Mt. Diablo Quicksilver Mining Co., Ltd., P.O. Box 133, Clayton	E½ 29	1N	1E	MD	Ore bodies of metacinnabar and cinnabar in fracture zones near footwalls of tabular serpentine masses in Franciscan rocks. Mined on surface and underground. Production from 1875-77 unknown. Principal production 1936-46. Also produced 1951-52. Total production 11,000+ flasks. DMEA exploration loan, $125,000, in 1955. Idle 1956-58. (R 8:162; 23:21; 35:374-375; B 27:195; 78:41; USGS B 922-B:31-54; USGS M13:378.)

MINERAL WATER

	Alhambra Springs	Alhambra Water Co., c/o E. R. and L. W. Lasell, 700 Castro St., Martinez	7	1N	2W	MD	Group of six springs near Martinez. Water bottled and sold 1904-51. (R 23:16-17; USGS WSP 338:293-294; R 47:576 herein.)
14	Byron Hot Springs	Ralph H. Barr, 605 Market St., San Francisco	15	1S	3E	MD	Used by Indians prior to coming of white men. Developed as a resort since 1861. Inactive. (R 8:163; 11:193; 17:56-60; herein.)
	Marsh Creek Springs		NW¼ 34	1N	1E	MD	On Marsh Creek Road 5½ miles east of Clayton. Developed as a picnic resort during recent years. Active.
	Oak Springs	Roy Filmer, 330 Jackson St., San Francisco	3	1S	3W	MD	Near Orinda. Originally a domestic water supply. Water bottled and sold by Fox Water Co., Oakland, from 1934 to about 1951 (?). Daily production ranged from 300 to 1000 gallons. Inactive. (R 47:577.)

PEAT

Map No.	Claim, mine, or group	Owner name, address	Location: Sec.	T.	R.	B & M	Remarks
26	Gambetta, P. J.	Route 1, Box 78, Brentwood	NW¼2	2N	3E	MD (proj.)	Peat dredged from Frank's Tract and barged to drying yard at Indian Slough southeast of Brentwood. (B 176:405; herein.)
27	Vita Peat Corporation (Pacific Products Co., California Peat Co.)	F. E. Koser, Bethel Island	1, 2, 11, 12	2N	3E	MD (proj.)	Operated since before 1950, producing peat from Frank's and barging to drying yard west of Antioch bridge. Sedge peat now dredged from Frank's Tract and barged to drying yard at Bethel Island. Peat sold through distributors. (B 176:405; R 47:594; herein.)

PUMICE

Map No.	Claim, mine, or group	Owner name, address	Location: Sec.	T.	R.	B & M	Remarks
28	Alvarnez	M. Alvarnez, Route 1, Box 589, Pittsburg	15	2N	1W	MD	Pumice produced intermittently 1945-47. The pumice was used in an aggregate for lightweight building blocks at a small plant in Pittsburg. (R 47:578; B 174:31-32.)
29	Bailey Ranch	A. S. Bailey, Bailey Road, Pittsburg	23	2N	1W	MD	The deposit comprises a pumiceous tuff bed 40 feet thick, interstratified with sandstone and tuff beds which strike N 75° W, and dip 30° N. The pumiceous bed is covered by about 3 feet of sandy overburden. Pumice was produced, sized, and distributed to block plants in the San Francisco Bay area 1945-50. (R 47:578; B 174:31-32.)

ROCK PRODUCTS—BROKEN AND CRUSHED STONE, CRUSHED ROCK

30	Alves	Gene Alves, P.O. Box 950, Pittsburg	E½15	2N	1W	MD	Two pits in Pliocene sandstone and siltstone. About 3 miles west of Pittsburg. Used intermittently as sources of fill material by local contractors.
31	Alves	Gene Alves, P.O. Box 950, Pittsburg	NE¼22	2N	1W	MD	Inactive quarry about 3 miles west of Pittsburg in gently dipping Neroly sandstone (Miocene). Quarry is 300 feet long by 150 feet high by 300 feet wide. Beds, 5 to 10 feet thick, were loosened with shot and crushed for use as road base on State Route 4.
32	Antioch Paving Co.	F. S. Arata et al., RFD 1400, Antioch	SW¼25	2N	1E	MD	Inactive pit in Pliocene conglomerate about 2 miles south of Antioch. Portable crusher used to produce sub-base. About 6000 tons removed in 6 weeks in 1957.
33	Ball	F. A. Marshall, Danville	N½36(?)	1N	2W	MD (proj)	Inactive quarry 1½ miles east of Walnut Creek in San Pablo group fossiliferous conglomerate. Operated by N. M. Ball Sons 1947-48. Rock loosened by blasting and bulldozed to portable crusher for use as fill. (Davis and Vernon 51:585.)
	Bates, Boreland and Ayer						Operated Old Stege quarry from about 1900-18. (Huguenin and Castello 20:61.) See Old Stege.
34	Blake Bros. (San Pablo)	Blake Bros., Box 1002, Richmond	15, 16	1N	5W	MD (proj)	Franciscan sandstone quarry worked since 1907, on San Pablo Ridge. Rock blasted by coyote-hole method and crushed for riprap, railroad ballast, aggregate. (Huguenin and Castello 20:63-64; Laizure 27:21-23; Davis and Vernon 51:585-586; herein.)
35	Brooks Island (Healy-Tibbitts)	Healy-Tibbitts Construction Co., 411 Brannan St., San Francisco (1927)	25	1N	5W	MD (proj.)	Inactive quarry in Franciscan sandstone on San Pablo Ridge. Crushed for use as riprap and fill in late 1920's. (Laizure 27:23; Davis and Vernon 51:606.)
	Bruce		15	1N	4W	MD (proj)	Temporarily operating portable crushing plant in Old Stege quarry. Tractor rips Franciscan serpentine. (Herein.) See Old Stege.

ROCK PRODUCTS—BROKEN AND CRUSHED STONE, CRUSHED ROCK—Continued

Map No.	Claim, mine, or group	Owner name, address	Location				Remarks
			Sec.	T.	R.	B & M	
	Central Construction Co.						Operated Old Stege quarry in late 1920's. (Laizure 27:23, 24.) See Old Stege.
36	Christen	P. L. Davison, Route 1, Box 297, Martinez	34	2N	2W	MD (proj)	Inactive quarry in Tertiary sandstone, ½ mile West of Pacheco. Stone used locally prior to 1920 for road base. (Aubury 06:315; Huguenin and Castello 20:61; Laizure 27:25; Davis and Vernon 51:606.)
37	Diablo	Not determined	34	2N	4W	MD (proj)	Inactive quarry in Briones sandstone 4 miles east of San Pablo. Intermittently used as source of crusher-run base materials.
38	El Cerrito (Stege, Hutchinson)	Subdivided	22	1N	4W	MD (proj)	Inactive quarry in Franciscan sandstone in El Cerrito. Crushed rock produced here from 1906-44 by Hutchinson Co. (Aubury 06:317; Huguenin and Castello 20:65; Laizure 27:25-27; Davis and Vernon 51:607.)
39	Gallagher and Burke	Gallagher & Burke, 344 High St., Oakland	26	1N	2W	MD (proj)	Intermittently active quarry in San Pablo (Briones?) sandstone, ½ mile north of Walnut Creek. Portable crusher used to provide fill or imported sub-base for state roads. (Herein.)
	Harrison-Birdwell						Produced crushed rock from Franciscan metavolcanics from 1947-54. See Pacific Cement and Aggregates Co. (Davis and Vernon 51:586-587.)
	Healy-Tibbitts						Produced crushed Franciscan sandstone in 1920's. See Brooks Island and Point Molate quarries.
	Hutchinson Co.						Produced crushed Franciscan sandstone from 1906-44. See El Cerrito and Richmond.

40	Immel	Gallagher & Burke, 344 High St., Oakland	26	1N	2W	MD (proj)	Inactive pit in steeply dipping Briones (?) sandstone ½ mile north of Walnut Creek. Sandstone was used locally as fill and road base.
41	Kaiser, H. J.	Henry J. Kaiser Co., 1924 Broadway, Oakland (1951)	SW¼ 3	1S	3W	MD	Inactive quarry 1 mile southeast of Orinda in steeply dipping Moraga volcanics. Operated until 1954 for crusher-run base. Davis and Vernon 51:587-588.)
42	Kaiser, H. J.	L. Mangini, Clayton	NE¼ 22	1N	1W	MD	Active quarry 1 mile southwest of Clayton in Franciscan metavolcanic rocks. Crusher-run base produced here since 1954. (Herein.)
43	Martin	Not determined	NE¼ 6	1N	1W	MD (proj)	Eocene sandstone (10-foot outcrop) 1½ mile southeast of Concord, is being stripped to provide fill material. (Herein.)
44	Mt. Diablo Rock and Asphalt Co.	A. Schwartz, Clayton	NW ¼ 29	1N	1E	MD	Inactive pit in talus deposit on northeast flank of Mt. Diablo 1¾ miles southeast of Clayton. Deposit contains fragments of Franciscan group rock types. Operated from 1953-56 producing crusher-run base.
45	Oakland, Antioch & Eastern R. R. Co.	East Bay Municipal Utility District, Oakland (?)	SE¼ 24 (?)	1S	3W	MD (proj)	Inactive quarry in Moraga volcanics, 1 mile south of Moraga along railroad. Crushed for railroad ballast (Huguenin and Castello 20:63.)
46	Old Stege (Bates, Boreland & Ayer; Central Construction Co., Bruce)	Mt. Diablo Council Boy Scouts of America, Camp Hearns, 1290 Arlington, El Cerrito	15	1N	4W	MD (proj)	Crushed rock quarry in Franciscan group rocks 1 mile east of El Cerrito. Worked by Bates, Boreland & Ayer 1900-18, Central Construction Co. in 1920's. Now is site of Boy Scout campgrounds. Don Bruce temporarily active here enlarging grounds. (Laizure 27:23-25; Davis and Vernon 51:610.)
47	Pacific Cement and Aggregate, Clayton #135	Murchio Bros., Brentwood	NW ¼ 23	1N	1W	MD	Quarry in Franciscan metavolcanics 1 mile south of Clayton operated by Harrison Birdwell 1947-54. Crusher-run base produced here. (Herein.)
48	Point Isabel	Berkeley Waterfront Co., c/o Santa Fe Railway Co., 121 E. 6th St., Los Angeles (1951)	29	1N	4W	MD (proj)	Abandoned crushed rock quarry in Franciscan sandstone in Richmond. Now used by Rod and Gun Club. (Davis and Vernon 51:610.)

ROCK PRODUCTS—BROKEN AND CRUSHED STONE, CRUSHED ROCK—Continued

Map No.	Claim, mine, or group	Owner name, address	Location				Remarks
			Sec.	T.	R.	B & M	
49	Point Molate (Healy-Tibbets Co.)	North Bay Realty Co., Box 1126, Richmond; leased to U. S. Navy.	9	1N	5W	MD (proj)	Abandoned crushed rock quarry in Franciscan sandstone in Richmond operated by Healy-Tibbets Co. in 1920's. Stone was shipped by barge. Now used as oil storage sump. (Huguenin and Castello 20:62-63; Davis and Vernon 51:611.)
	Point Richmond						See Richmond. (Huguenin and Castello 20:63.)
50	Richmond (Point Richmond, Hutchinson Co.)	Richfield Oil Co., Richfield Bldg., Los Angeles	23	1N	5W	MD (proj)	Abandoned crushed rock quarry in Richmond, in Franciscan sandstone. Operated by Hutchinson Co. 1915 to late 1920's. Quarry was worked below sea level. Now flooded. (Huguenin and Castello 20:63; Laizure 27: 27; Davis and Vernon 51:612.)
	San Pablo						See Blake Bros. (Huguenin and Castello 20:63-64.)
	Serra Bros.						Operating Slater quarry since 1946. Produce crushed rock from Sobrante sandstone. (Davis and Vernon 51:588 Herein.) See Slater.
51	Slater (Serra Bros.)	C. C. Slater, Route 1, Box 369, Martinez	34	2N	2W	MD (proj)	Quarry in Sobrante sandstone ½ mile south of Pacheco intermittently active from 1906-20's. Reopened in 1942 to provide fill for Buchanan Air Base. Worked by Serra Bros. since 1946. (Aubury 06:317; Huguenin and Castello 20:64-65; Laizure 27: 27, 29; Davis and Vernon 51: 588; herein.)
	Stege						See El Cerrito. (Aubury 06:317; Huguenin and Castello 20:65.)
52	Tunnel Rock	A. C. Goerig, 220 Tunnel Road, Orinda	SW¼ 9	1S	3W	MD	Crushed rock quarry in Berkeley Hills, ¾ mile east of Broadway Tunnel in Moraga volcanic rocks. Operated since 1951 for crusher-run base. (Herein.)

53	Unnamed	J. Mendoca, Route 1, Box 588, Pittsburg	NE¼ 16	2N	1W	MD	Abandoned crushed rock quarry 3 miles east of Port Chicago in Neroly sandstone. (Davis and Vernon 51:614.)
54	Unnamed	Ginochio Bros., Route 1, Box 6, Antioch	12	2N	2W	MD (proj)	Abandoned pit in Pliocene shale and conglomerate ¼ mile south of Port Chicago. Used as fill. (Davis and Vernon 51:614.)
55	Unnamed	Ginochio Bros., Route 1, Box 6, Antioch	NW¼ 7	2N	1W	MD	Abandoned pit in Pliocene shale and conglomerate ¾ mile southeast of Port Chicago. Used as fill. (Davis and Vernon 51:614.)
56	Unnamed	Richfield Oil Co., Richfield Bldg., Los Angeles	23	1N	5W	MD (proj)	Abandoned crushed rock quarry in Franciscan sandstone in Richmond. (Davis and Vernon 51:614.)
57	Unnamed	Not determined	SE¼ 35	1N	1E	MD	Abandoned quarry 5 miles southeast of Clayton in Cretaceous sandstone.
58	Unnamed	F. S. Arata et al., (?), RFD 1400, Antioch	E½ 25	2N	1E	MD	Abandoned pit 2 miles south of Antioch in Pliocene conglomerate.
59	Unnamed	G. Gill et al., Clayton	NW¼ 1	1N	1E	MD	Abandoned quarry 3½ miles south of Antioch in Eocene sandstone.

ROCK PRODUCTS—SAND (including Specialty Sand)

	Antioch-Marchio Sand						High-silica foundry sand produced by Marchio Sand Co. (Wright 48:40.) See Marchio Sand Co.
	Antioch Sand Plant						(Huguenin and Castello 20:61.) See Antioch Sand Co.
	Antioch Sand Co. (Antioch Sand Plant)	Crown Zellerbach Co., Antioch	SW¼ 17	2N	2E	MD	Pit in dune sand 1.4 miles east of Antioch active until 1950. Now site of Crown Zellerbach paper plant. (Huguenin and Castello 20:61; Laizure 27:29-31; Davis and Vernon 51:580.)
	Basalt Rock Co.	Kaiser Gypsum Co., Antioch	SE¼ 18	2N	2E	MD	Inactive. Worked dune sands from 1936-52. (Davis and Vernon 51:580.)

ROCK PRODUCTS—SAND (including Specialty Sand—Continued)

Map No.	Claim, mine, or group	Owner name, address	Location				Remarks
			Sec.	T.	R.	B & M	
60	Black Diamond (Columbia Steel, Roberts, T. G., Roberts, E., Roberts Bros., Roberts Sand Co., Silver Sand Co.	Southport Land and Commercial Co., 220 Montgomery St., San Francisco	SE¼ 5	1N	1E	MD	Old coal mine at Nortonville. Worked for sand from 1925-49 by Columbia Steel, Roberts et al.; reopened in 1957 by Silver Sand Co. (Laizure 27:19; Davis and Vernon 51:583.)
	Brentwood						Area of glass and foundry sand production from 1920-42. Eastern extension of belt of Domengine sandstone from Nortonville-Somersville. See Longwell Ranch and Stonehouse Ranch.
	Columbia Steel Co.						Produced molding sand prior to 1925 from Longwell Ranch central pit (Brentwood area). Produced sand at Black Diamond mine through 1930. (Laizure 27:19; Davis and Vernon 51:583.)
	Contra Costa County	S. L. Longwell, Box 292, Brentwood	SW¼ 1	1S	2E	MD	Sand quarried intermittently from Longwell Ranch south pit for use as road base (herein.)
61	Cowell (Silver Sand Co., Laws)	Henry Cowell Lime & Cement Co., 2 Market St., San Francisco	8	1N	1W	MD (proj)	Deposit of Domengine sandstone located approximately 3 miles southeast of Concord, formerly quarried as source of silica for cement. Now worked by Silver Sand Co. and Chas. Laws (Davis and Vernon 51:581; herein).
	Hazel-Atlas Glass Co.						Produced glass sand from old Pittsburg coal mine, Somersville, from 1932-37. See Pittsburg mine and Pittsburg Sand Co. (Davis and Vernon 51:583.)
62	Henry J. Kaiser Co.	Southern Pacific Co., 65 Market St, San Francisco	NE¼ 28	2N	2E	MD	Inactive sand pit 3 miles southeast of Antioch, operated from 1937-51. (Davis and Vernon 51:580.)

	Holland Sandstone Brick Co.		18 (?)	2N	2E	MD	Sand pit active briefly around 1920. Located 1 mile east of Antioch. Unsuccessfully attempted to make bricks with sand. (Huguenin and Castello 20:61.)
	Laws	Henry Cowell Lime and Cement Co., 2 Market St., San Francisco	8	1N	1W	MD (proj)	Portion of Cowell sand pit mined for use in asphaltic shingle by Chas. Laws. (Herein.) See Cowell.
63	Longwell Ranch, Central Pit (Columbia Steel Co.)	S. L. Longwell, Box 292, Brentwood	SW¼ 6	1S	3E	MD	Inactive deposit of Domengine sandstone located about 4 miles south of Brentwood; mined for foundry sand during 1920's by Columbia Steel Co. (Davis and Vernon 51:584.)
64	Longwell Ranch, North Pit (Silica Co. of California)	S. L. Longwell, Box 292, Brentwood	NW¼ 6	1S	3E	MD (proj)	Inactive deposit of Domengine sandstone located about 4 miles south of Brentwood. Silica Co. of California mined sand for glass and foundry from 1934-38, using underground methods. (Davis and Vernon 51:584.)
65	Longwell Ranch, South Pit (Silica Co. of California, Contra Costa County)	S. L. Longwell, Box 292, Brentwood	SE¼ 1	1S	2E	MD	Deposit of Domengine sandstone located about 4½ miles south of Brentwood. Worked by Silica Co. of California from 1938-42 by surface methods. Now used intermittently by Contra Costa County as source of road-building material. (Davis and Vernon 51:584.)
66	Marchio Sand Co.	L. Ginochio, Route 1, Box 6, Antioch	NW¼ 11	1N	1E	MD	Inactive pit in Domengine sandstone about 4½ miles south of Antioch formerly mined for foundry sand. (Davis and Vernon 51:581.)
67	Marchio Sand Co. (Star mine)	L. Ginochio, Route 1, Box 6, Antioch	SE¼ 11	1N	1E	MD	Produces foundry sand from Domengine sandstone at old Star coal mine; located about 4½ miles south of Antioch. (Davis and Vernon 51:581; herein.)
68	Morris Sand Co., McCullough	G. Stamm, 5th and B Streets, Antioch	SE¼ 18	2N	2E	MD	Pit in dune sand near Antioch excavated for bituminous mix. (Laizure 27:31; Davis and Vernon 51:580; herein.)
	Nortonville						Old coal-mining area. Site of Black Diamond mine, from which foundry sand was produced 1925-49. See Black Diamond.

ROCK PRODUCTS—SAND (including Specialty Sand—Continued)

Map No.	Claim, mine, or group	Owner name, address	Location: Sec.	T.	R.	B & M	Remarks
69	Pittsburg (Hazel Atlas Glass Co., Pittsburg Sand Co.)	Southern Pacific Co., 65 Market St., and L. Ginochio, Route 1, Box 6, Antioch	SE¼ 4	1N	1E	MD	Old coal mine at Somersville later worked for sand by Hazel-Atlas Glass Co., by room and pillar method 1932-37, and subsidiary Pittsburg Sand Co., 1937-45. (Davis and Vernon 51:583.)
	Pittsburg-Roberts						Foundry sand produced by Roberts Sand Co. at Black Diamond mine, Nortonville (Wright 48:42). See Black Diamond.
	Pittsburg Sand Co.						Subsidiary of Hazel Atlas. Produced glass sand from Pittsburg mine, Somersville, from 1937-45. (Davis and Vernon 51:583.) See Pittsburg.
	Roberts Bros.						Mined foundry sand at Black Diamond coal mine in 1940. (Davis and Vernon 51:583.) See Black Diamond.
	Roberts, E.						Mined foundry sand at Black Diamond mine, 1935-38. (Davis and Vernon 51:583.) See Black Diamond.
	Roberts, T. G.						Mined foundry sand at Black Diamond mine, 1931-32. (Davis and Vernon 51:583.) See Black Diamond.
	Roberts Sand Co.						Mined foundry sand at Black Diamond mine, 1941-49. (Davis and Vernon 51:583.) See Black Diamond.
	Scheller						Inactive pit in dune sand 1 mile east of Antioch. (Huguenin and Castello 20:65.)
	Silica Co. of California						From 1929-42 produced glass and foundry sand from Domengine sandstone near Brentwood. See Stone House Ranch and Longwell Ranch north and south pits. (Sampson and Tucker 31:436-437, Davis and Vernon 51:584.)

	Silver Sand Co.	P.O. Box 5, Cowell	8	1N	1E	MD (proj)	Quarry Domengine sandstone in Cowell pit and at Black Diamond coal mine (herein).
	Somersville						Old coal mining area. Site of Pittsburg mine from which glass sand was produced 1932-45. See Pittsburg.
	Star						Old coal mine in Domengine formation. Now site of open-pit operation of Marchio Sand Co. See Marchio Sand Co. (Crawford 94:46-48.)
70	Stone House Ranch	Henry Cowell Lime & Cement Co., 2 Market St., San Francisco	36	1N	2E	MD (proj)	Inactive deposit of Domengine sandstone located approximately 3 miles southwest of Brentwood. Room and pillar mining method used by Silica Co. of California from 1929-34 to obtain foundry sand. (Sampson and Tucker 31:436-437; Davis and Vernon 51:584.)
71	Wills	J. Little, Route 1, Box 101, Antioch	SW¼ 17	2N	2E	MD	Pit in sand dunes 1½ miles east of Antioch excavated for use as fill and select import. (Davis and Vernon 51:580; herein.)

ROCK PRODUCTS—DIMENSION STONE

Franklin	Not determined	24(?)	2N	3W	MD	Inactive. Sandstone quarried in 1890's from Martinez formation for use as building stone (Aubury 06:126).
Martinez	Not determined		2N	2W	MD	Inactive. Located three-fourths of a mile southwest of Martinez. Martinez sandstone used in Napa State Hospital in 1890's (Aubury 06:126).
McNears	Not determined		2N	3W	MD	Inactive. Located on line of Southern Pacific RR between Martinez and Port Costa; sandstone used at Port Costa in 1890's. (Crawford 94:398.)

RESEARCH IN MINING AND THE MINERAL INDUSTRIES IN CALIFORNIA

An interim report to the State Legislature prepared jointly by the University of California and the State Department of Natural Resources

CONTENTS

FOREWORD

The Western Governors Mineral Policies Conference, comprised of 500 leading representatives of the mineral industries in the western states, met in Sacramento in 1955 and recommended to the Western Governors Mining Advisory Council serious consideration of a strong program of research as the "foundation upon which growth of the mineral industries must depend." The policy stated that "For the future health of the mineral industries and of the entire national economy, there should be vigorous research activity supported directly by private industry as well as by state and federal agencies, each working in the sphere for which it is best fitted."

At the 1957 session of the State Legislature, Assembly Bill 1607 was passed allocating $500,000 per year to the State Division of Mines for basic research and field studies in the mineral industries. This bill was subsequently vetoed by the Governor. However, Senate Concurrent Resolution No. 84 was passed requesting the State Department of Natural Resources and the University to "prepare a program and recommendations jointly to the Legislature at the convening of its 1958 Session, on needed basic research and field studies regarding minerals and the mineral industries, . . ." Following is the verbatim report transmitted to the Legislature in response to this Resolution. A final report, including estimated budgets of the University and the State Department of Natural Resources necessary to implement the proposed programs, will be submitted to the 1959 Session of the State Legislature.

State Division of Mines
San Francisco, May 1958.

LETTER OF TRANSMITTAL TO THE STATE LEGISLATURE

March 24, 1958

STATE DEPARTMENT OF NATURAL RESOURCES
THE UNIVERSITY OF CALIFORNIA

We have the honor to present a joint interim report on studies and preliminary plans for basic research and field studies dealing with all phases of mining and the mineral industries prepared by the State Department of Natural Resources and the University of California, in response to Senate Concurrent Resolution No. 84.

California's annual mineral production has now reached the value of $1.6 billion dollars, a source of new wealth second only to agricultural products. Most of the readily accessible and obvious mineral deposits in the State have been discovered and are being exploited. If new sources of mineral raw materials are to be located and developed, all modern methods of exploration and field studies must be employed. Detailed geologic mapping of rock formations and mineral deposits, development and application of geophysical and geochemical methods, and fundamental studies of the origin of ore deposits can lead to the development of new and more efficient exploration tools. Improvement in mining and production methods through research in cheaper and more efficient drilling and extraction practices can increase yield of valuable mineral products. Research in beneficiation of ores, and in methods of concentrating and separating many types of nonmetallic raw materials is leading to the successful exploitation of deposits heretofore considered uneconomic. Knowledge of the uses of minerals by industry in California, and of the specifications required by industry, is a fruitful field for research. Research in this field of mineral utilization leads to the development of new markets and new industries, and to increased use of mineral raw materials produced in California.

The interim report herewith submitted states the policies, the broad areas of basic research and field studies, and the general types of organization proposed to achieve the objectives outlined in Senate Concurrent Resolution 84. In developing this report, it became increasingly evident that additional time will be needed for more detailed study, particularly by the University, before a final report and recommendations can be prepared. Accordingly, unless advised otherwise, we will submit a final report to the 1959 Session.

Enclosures: SRC No. 84
Interim Report

Respectfully submitted,

(signed) DEWITT NELSON, Director
Department of Natural Resources

(signed) ROBERT G. SPROUL, President
University of California

SENATE CONCURRENT RESOLUTION NO. 84*—RELATIVE TO A PROGRAM OF BASIC RESEARCH AND FIELD STUDIES DEALING WITH ALL PHASES OF MINING AND THE MINERAL INDUSTRIES

WHEREAS, Mining and the mineral industries constitute a major factor in the economy of California and the western area of the United States generally; and

WHEREAS, Recent conferences, and particularly the Western Governors' Mining Advisory Council held at Sacramento in November, 1955, have emphasized the need for appropriate research and field studies on all phases of mining and the mineral industries for the proper development and utilization of our mineral resources; now, therefore, be it

Resolved by the Senate of the State of California, the Assembly thereof concurring, That the State Department of Natural Resources and the University of California are requested to prepare a program and recommendations jointly for presentation to the Legislature at the convening of its 1958 Session, on needed basic research and field studies regarding minerals and the mineral industries, particularly on exploration, mining, production, beneficiation, and utilization of minerals, ores, and metals; and be it further

Resolved, That the Secretary of the Senate is hereby directed to transmit copies of this resolution to the State Department of Natural Resources and the Regents of the University of California.

PRELIMINARY DRAFT OF JOINT REPORT FROM THE STATE DIVISION OF MINES AND THE UNIVERSITY OF CALIFORNIA

Introduction

The Chief, Division of Mines, appointed the following committee to consider research in this field by the Division: Oliver E. Bowen, Jr.; Charles W. Chesterman; Olaf P. Jenkins, Chief, Division of Mines; Gordon B. Oakeshott, Chairman, Research Committee; Lauren A. Wright and Richard M. Stewart.

President Sproul appointed a University-wide committee to study the ways in which the University might participate in "basic research and field studies regarding minerals and mineral industries, particularly on exploration, mining, production, beneficiation, and utilization of minerals, ores, and metals". The membership of this committee was: Professors Donald Carlisle, George C. Kennedy, Earl R. Parker (Chairman), Francis J. Turner, and Robert W. Webb.

Each committee met separately and drafted preliminary reports. The State Division of Mines committee submitted its preliminary report to the Director of Natural Resources and the University committee submitted its report to the President of the University. Copies of the report were exchanged by the two institutions. Meetings of representatives of the two groups were held, and the following preliminary draft of a joint report was prepared. The need for additional research in the mineral field was pointed out and the roles that could be played by

* Resolution passed by the State Legislature at the 1957 Session.

the State Division of Mines and the University of California were indicated.

It was evident that additional time was needed for more detailed study, particularly by the University, before a final report and recommendations could be prepared; consequently, the statements regarding the possible participation of the University should not be construed as a commitment by the University to a new or expanded program at this time. During the coming year, the State Department and the University will prepare detailed plans and recommendations.

Premises and Observations

The gross imbalance between anticipated demands for mineral materials in the American economy, on the one hand, and projected economic supplies from domestic mines, on the other hand, has been extensively discussed in numerous authoritative reports. Notable among these are the Report of the President's Materials Policy Commission (Paley Report, 1954), the earlier "Krug Report", the Report of the Advisory Committee on Minerals Research to the National Science Foundation (1956), and the Recommendations from the Western Governors Mineral Policies Conference (1955).* The urgency of this situation has been accepted as a premise by the Committee in its discussions and recommendations. It will not be reviewed further here.

The University committee recognizes that a vigorous mining industry is an important source of wealth to the nation and to the State. It notes that the American mining industry has faced increasing competition from foreign suppliers as higher grade domestic reserves have been depleted and as costs of production in the United States have risen in relation to the prices obtained for most materials. The committee believes that this situation can be alleviated somewhat by research directed toward the discovery of hidden workable deposits and toward means to exploit lower grade sources of minerals at real costs not greatly out of proportion to the efforts now expended in mineral production.

New discoveries, new economies, and expansion of the domestic mining industry are likely to be engendered by an expansion of knowledge in all of the areas, geological, technological, and economic, that make up the environment of the mineral industry. Research is the foundation upon which future growth of the mineral industry depends.

It is an appropriate function of the nation and the State to take steps to promote research, especially in those fields of interest to the mining industry that private agencies will not or cannot fully cover. It is also their appropriate function to discover and to establish an economic environment that will be conducive to the wisest use of mineral resources.

Endorsement of Report of the Research Committee Western Governors Mineral Policies Conference

The following recommendations for research, which the State Division of Mines and the University endorse, were taken from the report of the Western Governors Mineral Policies Conference:

* California Division of Mines, 1956, Recommendations for a national minerals policy, from the Western Governors Mineral Policies Conference: California Jour. Mines and Geology, October, pp. 597-655.

"Research is the very foundation upon which future growth of the mineral industries must depend. However, because of certain economic factors some segments of the industry have lagged behind in their research developments. This is particularly true in the fields of mineral exploration. To correct this situation and—by expanding research activity—to insure a continued healthy growth to the industry, we recommend that the following steps be taken:

1. Establish federal and state sponsored mineral research programs at various appropriate universities and nonprofit research foundations.
2. Grant a certain portion of state tax revenues and obtain federal funds to support such research programs.
3. Continued support of basic research in federal agencies.
4. Establish, in each of the mining states, a clearinghouse or library of pertinent technical information dealing with all phases of the mineral industries.
5. Establish at both state and federal levels a permanent minerals research advisory board."

It should also be pointed out that the chairman of the State Mining Board held open meetings for a discussion of research problems at (1), San Francisco; and (2), Los Angeles. These meetings were attended by representatives of industry and staff members of a number of universities in the State; discussions were held on the subject of mineral research in the State of California. Also, a series of talks on the subject of minerals research in California has recently been completed before the Minerals Industries section of the Commonwealth Club in San Francisco. At these meetings unofficial discussions of research programs were presented by representatives of Stanford University School of Mineral Sciences, the U. S. Bureau of Mines, the California State Division of Mines, and the Division of Mineral Technology of the University of California.

Functions of the State Division of Mines and The University in the Minerals Field

The State Division of Mines, organized in 1880, is primarily a public information bureau which has as its principal purpose the providing of useful information to the mineral industry of California. The Division of Mines must seek information through its own field activities, office and laboratory research, and makes use of all available sources of information from other agencies and individuals, including published and unpublished materials.

The University of California is an educational institution with primary responsibility of acquiring and disseminating knowledge. Instruction and research in the fields of minerals and metals are appropriate functions of the University.

Examples of New or Expanded Activities Appropriate for the Division of Mines

An expanded program of activities by the Division should include:

I. Geological Mapping. Only about one-tenth of the state has been adequately mapped on the 1:62,500 scale. A regular, orderly program

should be undertaken to complete such mapping on the new topographic base maps. This would aid in obtaining more complete knowledge of the mineral resources and potential of the state and would supply maps of fundamental importance for all types of engineering projects and land utilization studies. The 1:62,500 mapping project should be accompanied and followed by detailed large-scale mapping of all mineralized areas and mineral deposits.

One reason for the direct economic importance of geologic mapping lies in the fact that certain mineral deposits are developed in, or associated with, mappable rock formations. For examples:

A. Presently operated, commercial deposits of diatomaceous earth are in a marine sedimentary formation of upper Miocene age. Therefore, a geologic map showing the distribution of similar formations in California is the logical beginning of exploration for new deposits of diatomaceous earth.

B. The massive copper-zinc-iron sulfide deposits of the west Shasta district occur only in the Balaklala rhyolite of Devonian age. A geologic map of this formation is the best indication of where additional massive sulfide deposits in the area may occur.

II. Mineral Utilization. Knowledge concerning the actual use of California minerals by industry, and the specifications industry requires, is inadequate. Field research in this phase of mineral economics should be carried on at a greatly accelerated rate. For example:

A. Research on the use of barite and the specifications required by industry for utilization in drilling muds might increase the market for known deposits of California barite.

III. Beneficiation of Ores and Metallurgical Research. These areas of research require very large outlays for laboratory plants, equipment, and specialized personnel. The U. S. Bureau of Mines, the University, and certain technical institutes are now being equipped to handle such problems. It would seem advisable for the State Division of Mines to use its research funds in these fields to contract with these agencies to cooperate on specific research problems of greatest importance to the state, thus ensuring that California's problems will receive adequate emphasis. This would require State funds and administrative time of the Division, but no State personnel. Examples are:

A. California has numerous deposits of low-grade, high-silica manganese ore. One of the possibilities of utilizing such ore lies in research in its direct treatment to produce ferromanganese.

B. California's numerous small bodies of chrome ore are usually high in iron. Research may succeed in direct smelting of such ores to produce ferrochrome alloys, thus increasing development and mining of California chromite.

IV. Commodity Research. Expanded research on each mineral commodity, including geologic occurrence, reserves, production, utilization and development of new uses. The complete commodity research contemplated would require the appropriate use of modern field and laboratory equipment and techniques, including geophysical equipment,

geochemistry, physical laboratory equipment, a modern analytical chemical laboratory and the personnel to operate the equipment.

The importance of mineral research for California may be emphasized by selecting a few mineral commodities, more or less at random, to illustrate what might be done by the Division of Mines.

A. *Aggregate Materials.* Aggregates now constitute one of the most important mineral commodities to the state, involving such things as the construction of our highways and, in fact, all phases of our great construction program. While the Division has a great deal of available information on aggregate materials in California, a phase which has been almost totally neglected is laboratary testing and research to determine the relation of texture, structure, and mineral composition to strength characteristics, porosity, and reactivity and methods by which the usefulness of a given rock as aggregate can be determined.

B. *Limestone, dolomite, and other carbonate rocks* are economically important to the state. The Division has obtained important information on these commodities and has become increasingly valuable to the cement industry in the past few years. However, we need complete data involving mapping, sampling, determination of specifications, and study of markets, to obtain fundamental useful knowledge on carbonate rocks in the state. We lack, for example, such elementary knowledge as the actual mapped distribution and analyses of the state's deposits of carbonate rocks.

C. *Lateritic nickel* deposits derived from serpentine rocks have now been proven commercially in the Riddle, Oregon, areas. The Division should undertake large scale investigations of lateritic nickel deposits of the Klamath Mountains and the Sierra Nevada foothills. Incidentally, there should be even more widespread studies of the serpentine and periodotite rocks to determine the commercial potential of the minerals in such rocks, including asbestos, chromite, mercury and magnesite.

D. *Talc* is one commodity in which the Division has been carrying on geologic mapping and research for many years. However, almost nothing is known of the occurrence and properties of the low grade talcose materials called soapstone. Mapping of such deposits, petrographic and chemical analyses, and study of specifications and markets are needed.

V. Petrographic and Mineralogic Research. Study of the composition, properties, and characteristics of the rocks and minerals themselves, a long-range program designed to bring increased fundamental knowledge of California's minerals substances; this is basic to the entire mineral industry. Examples are:

A. Mineralogical, petrographic, and chemical study of the Ogilby kyanite rocks; research needed to bring about utilization of this unique group of high-alumina rocks in southeastern California.

B. Mineralogical and petrographic study of the serpentine rocks to determine their commercial potential for chromium, nickel, cobalt, asbestos, and magnesia.

VI. Mining Methods and Mine Problems. The U. S. Bureau of Mines is currently best equipped to handle research in those areas. The State Division of Mines should contribute cooperative funds to support and accelerate studies on problems of greatest importance to California. Sharp cuts in costs can come from investigation in this field. Of interest in this regard is work by the University of California and the U. S. Bureau of Mines who are conducting research in new methods for breaking of rock. One study, in which the University has cooperated, involves the use of nuclear energy in explosives. State support of such projects is suggested by cooperative funds through the Division of Mines to the University or Bureau.

VII. Extension of Information Service. The Division of Mines should act as a central coordinating agency for information on the mineral industry field in California. It presently maintains extensive mineral exhibits and a library with comprehensive coverage of the mineral industry. The Division's usefulness could be increased by maintaining a file on minerals and research projects underway by the various agencies which are operating in the State, and being responsible for disseminating such information to interested parties.

Examples of New or Expanded Activities Appropriate for the University

The University should concentrate its efforts on acquiring new knowledge about the problems of geology, geochemistry, and geophysics because it is only through new knowledge that it will become possible to devise new methods for discovering new ore bodies presently undetectable because they are covered and hidden from view. Similarly appropriate is research in exploration, mining methods, and beneficiation, that will provide the knowledge needed to make the economic utilization of the large deposits of certain low grade minerals (e.g., those containing chromium, nickel, and manganese) now known to exist in California but from which metals cannot now be extracted at a profit. Also, research can lead to new uses for minerals presently considered useless. Some examples of typical problems are given below to illustrate the scope of needed research:

I. Geological Research

A. Ore-forming processes
   1. Metamorphic and metasomatic processes.
   2. Magmatic processes.
   3. Pegmatitic and hydrothermal processes.
   4. Sedimentary and diagenetic processes.
   5. Weathering and enrichment.

B. Environment of ore deposition
   1. Regional problems.
   2. Local problems.

C. Special problems and techniques
   1. Laboratory problems.
   2. Field problems.
   3. Geologic mapping.
   4. Mapping of metallic and nonmetallic deposits.

II. *Geochemical Research*
- A. Study of fluids in sediments and volcanic rocks.
- B. Study of hydrothermal differentiation of igneous rocks.
- C. Study of environment of ore deposition.
- D. Isotopic studies bearing on ore deposition.
- E. Studies of instrusions with and without related ore deposits.
- F. Development of geochemical prospecting techniques for the discovery of hidden ore deposits.

III. *Geophysical Research*
- A. Investigation of rock properties.
- B. Investigation of magnetic properties of earth materials.
- C. Research in seismology.
- D. Investigation of electrical properties of rocks.
- E. Development of methods and equipment for geophysical prospecting for ores.

IV. *Mining and Production*
- A. Development of cheaper underground mining methods.
- B. Development of cheap and efficient methods for extracting, such as controlled leaching, for extensive low grade deposits that cannot be mined economically.
- C. Development of cheaper drilling methods.

V. *Beneficiation*
- A. Development of economical new chemical methods for concentrating minerals too low grade to be presently classed as ores.
- B. Development of economical new physical methods for concentrating minerals too low grade to be presently classed as ores.
- C. Make economic analysis of complex low grade deposits to determine feasibility of using several concentrates in different industries; e.g., Ione clay-sand deposits are presently useful only because purified clay is used by Gladding-McBean and clean sand is used by Owens-Illinois.

VI. *Extraction*
- A. Develop cheaper or better extraction processes.

VII. *Utilization*
- A. Determine properties of California minerals and products that can be made therefrom with the objective of finding new markets for presently unused materials.

VIII. *Economic Analyses*
- A. Study of incentives and decision making in mineral exploration and production.
- B. Operations and analysis applied to mineral production and utilization.
- C. Studies to determine most economic means to utilize State's mineral resources.

IX. Offshore Resources

A. Evaluate offshore mineral resources.
B. Investigate methods for recovery of offshore minerals.

A substantial amount of research on physicochemical, physical and chemical investigations of the properties of ores and ore bodies with their host rocks is being done within the University at the present time, primarily in the Departments of Geology at Berkeley and Los Angeles and the Institute of Geophysics at Los Angeles. These departments could increase their research activities if additional funds were supplied through the regular University budget.

Only a small amount of research in the University is directed toward the creation of devices or methods for locating new ore bodies, the devising of cheaper mining methods, the discovery of better ways to concentrate ores and to extract metals, and the finding of new uses for presently unused minerals. The Division of Mineral Technology in the College of Engineering, Berkeley, is primarily concerned with research of this kind. An expansion of this activity would involve a considerable expense because of the equipment and facilities needed. However, research could lead to a large increase in the natural wealth of the state.

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LIST OF MINES, QUARRIES AND GAS WELLS SHOWN ON MAP
Contra Costa County, California

Map no.	Property	Sec.	T.	R.[1]
	CLAY (Shale)			
1	Port Costa Brick Works	10	2N	3W*
2	United Material and Richmond Pressed Brick Co	23	1N	5W*
	COAL			
3	Black Diamond	SE 5	1N	1E
4	Central	10	1N	1E
5	Empire	12	1N	1E
6	Pacific	SE 22	1N	2E*
7	Pittsburg	SE 4	1N	1E
8	Star	SE 11	1N	1E
9	Teutonia	SW 7	1N	2E
	DIATOMITE			
10	Pawsey	22	2N	4W*
	LIMESTONE			
11	Cowell	17, 20	1N	1W*
	MANGANESE			
12	Red Rock Island	17	1S	5W*
	MERCURY			
13	Mt Diablo	29	1N	1E
	MINERAL WATER			
14	Byron Hot Springs	13	1S	1E
	NATURAL GAS			
	Standard Oil Co of Calif			
15	Bradford Community 1	20	3N	3E*
16	Bradford Community 2	20	3N	3E*
17	Bradford Community H 3	20	3N	3E*
18	Bradford Community 4	21	3N	3E*
19	Bradford Community 5	20	3N	3E*
20	Bradford Community 6	20	3N	3E*
21	Floto 1	28	3N	3E*
22	Floto 2	28	3N	3E*
23	Jordan Unit 1	29	3N	3E*
24	Jordan Unit 3	29	3N	3E*
25	McCulloch Oil Exploration Co	18	2N	1W
	PEAT			
26	Gambetta	2	2N	3E*
27	Vila Peat	2 11 (?)	2N	3E*
	PUMICE			
28	Alvarez	15	2N	1W
29	Bailey Ranch	23	2N	1W
	ROCK PRODUCTS—CRUSHED ROCK			
30	Alves	E½ 15	2N	1W
31	Alves	NE¼ 22	2N	1W
32	Antioch Paving Co	SW¼ 25	2N	1E
33	Ball	N½ 30 (?)	1N	2W*
34	Blake Bros (San Pablo)	15, 10	1N	5W*
35	Brooks Island (Healy Tibbets)	25	1N	5W*
36	Christen	34	2N	2W*
37	Diablo	34	2N	4W*
38	El Cerrito (Stege Hutchinson)	22	1N	4W*
39	Gallagher and Burke	26	1N	2W*
40	Immel	26	1N	2W*
41	Kaiser H J	SW¼ 3	1S	3W
42	Kaiser, H J	NE¼ 22	1N	1W
43	Martin	6	1N	1W*
44	Mt Diablo Rock and Asphalt Co	NW¼ 29	1N	1E
45	Oakland Antioch and Eastern R R	SE¼ 24 (?)	1S	3W*
46	Old Stege (Bates Boreland and Ayer Central Const Co Bruce)	15	1N	4W*
47	Pacific Cement and Aggregates	NW¼ 23	1N	1W
48	Point Isabel	29	1N	4W*
49	Point Molate (Healy Tibbets Co)	9	1N	5W*
50	Richmond (Point Richmond Hutchinson Co)	23	1N	5W*
51	Slater (Serra Bros)	34	2N	2W*
52	Tunnel Rock	SW¼ 9	1S	3W
53	Unnamed	NE¼ 16	2N	1W
54	Unnamed	12	2N	2W*
55	Unnamed	7	2N	1W
56	Unnamed	23	1N	5W*
57	Unnamed	SE¼ 35	1N	1E
58	Unnamed	E½ 25	2N	1E
59	Unnamed	NW¼ 1	1N	1E
	SAND			
60	Black Diamond (Columbia Steel Roberts Sand Co Silver Sand Co)	SE¼ 5	1N	1E
61	Cowell (Silver Sand Co Laws)	8	1N	1W*
62	Kaiser Henry J	NE¼ 28	2N	2E
63	Longwell Ranch—Central Pit (Columbia Steel Co)	SW¼ 6	1S	3E
64	Longwell Ranch—North Pit (Silica Co of Calif)	NW¼ 6	1S	3E*
65	Longwell Ranch—South Pit (Silica Co of Calif) Contra Costa Co	SE¼ 1	1S	2E
66	Marchio Sand Co	NW¼ 11	1N	1E
67	Marchio Sand Co (Star Mine)	SE¼ 11	1N	1E
68	Morris Sand Co (McCullough)	SE¼ 18	2N	2E
69	Pittsburg (Hazel Atlas Glass Co Pittsburg Sand Co)	SE¼ 4	1N	1E
70	Stone House Ranch (Silica Co of Calif)	36	1N	2E*
71	Wills	SW¼ 17	2N	2E

[1] Mt Diablo Base and Meridian
* Land lines were projected to facilitate plotting

GEOLOGIC MAP OF CONTRA COSTA COUNTY
SHOWING MINES, QUARRIES AND GAS WELLS